Foodservice HECU HEEU Focused Pilot

Final Report

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Executive Summary

The High-Efficiency Condensing Unit (HECU) and High-Efficiency Evaporator Unit (HEEU) Focused Pilot Program sought to overcome key barriers to the widespread use of high-efficiency remote condensing and evaporator units in commercial foodservice. Barriers include market awareness of the benefits of these high-efficiency technologies, contractor familiarity with the equipment, higher equipment purchase costs, lack of laboratory and field test data to support a measure package, and little understanding among program implementation and utility staff regarding equipment sales and distribution channels and customer purchasing habits.

To address these barriers, the proposed project included six main components:

1. Market characterization study
2. On-site equipment monitoring
3. Midstream incentives pilot
4. Qualified products list
5. Equipment energy regression modeling
6. Measure package development preparation

Market Characterization Study

The market characterization study involved dynamic market research on HECUs and HEEUs in the California commercial refrigeration market. Our research methods involved comparison to other state programs and interviews with program administrators, manufacturers, distributors, and trade ally managers. For measure application and potential, the study investigated the supply chain and demand drivers of HECUs and HEEUs. The project team also characterized constraints on the market, which include government regulations and energy-efficiency standards, market barriers (such as high initial costs and lack of awareness from contractors), and competitive positioning of various manufacturers and suppliers. This led to an analysis of key market barriers and recommendations on how to overcome them.

This study also examined current market trends, adoption rates for high-efficiency commercial refrigeration products, and the technical potential of a market-integrated midstream program for HECUs and HEEUs in California, and it surfaced growth opportunities and highlighted challenges and key market gaps for participants, such as coordination with supply chain manufacturers, distributors, and contractors.

Key findings from the Market Characterization Study are:

- Customer purchasing habits and stocking practices within the supply chain are key determinants of technology adoption
- Market factors and installation requirements impact the condensing unit and evaporator unit market differently

- Supporting HECU and HEEU systems rather than individual energy-efficiency components is key to accelerating adoption
- Market actor relationship building is critical to a successful energy-efficiency program

On-Site Monitoring

The on-site monitoring component of this focused pilot involved gathering data from 10 sites throughout California. The project team gathered data on the original equipment and the retrofitted high-efficiency models. The normalized and averaged takeaways from site monitoring are that retrofitted HECU and HEEU systems show energy savings in comparison to baseline equipment.

Midstream Incentive Pilot

The project team conducted a pilot midstream program that incentivized qualifying equipment sales from November 1, 2023, to May 31, 2024. Four distributors were enrolled as participating distributors and three of them submitted participating claims. A total of 33 units were incentivized. To better understand the distributors experiences, the project team conducted distributor interviews. Major takeaways from the midstream pilot and relevant information gathered during marketing characterization study and on-site monitoring pilot, are that:

- Incentives stimulated high-efficiency equipment sales
- All participating distributors would like to have a permanent incentive program
- Partnerships with manufacturers are needed to increase high-efficiency equipment inventory at distributors
- Contractor education is needed to ensure high-efficiency model awareness, incentive awareness, proper installation, and full operation of high-efficiency features.

Qualified Products List

Through the midstream incentive pilot and distributor feedback, the project team determined that the Qualified Products List submitted with the Preliminary Findings Report was a good representation of the available high-efficiency models. For the Draft and Final reports, the team made minor amendments to reflect market additions and changes. The Section 4. Qualified Products List includes 2,413 HECU models and 1,459 HEEU models.

Equipment Energy Regression Modeling

Note that the Equipment Energy “Regression” Modeling section was originally intended to be the Equipment Energy “Performance Simulation” Modeling section, because the project team assumed that baseline modeling would be necessary. However, the team was able to collect sufficient data to conduct regression modeling and determine savings from site monitoring.

Measure Package Development Preparation

Overall, results from this focused pilot determined that an active measure package; a statewide midstream point-of-sale incentive program; and ongoing partnerships with distributors, manufacturers, and contractors can help transform the market and overcome barriers to HECU and HEEU adoption while simultaneously reducing ratepayer operating costs, reducing energy demand, reducing energy use, and, in some cases, reducing the use of high-GWP refrigerants.

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Abbreviations and Acronyms

Acronym	Meaning
AR	accelerated replacement
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AWEF	annual walk-in energy factor
Btu	British thermal unit
CARB	California Air Resources Board
CPUC	California Public Utility Commission
CU	condensing unit
DAC	disadvantaged communities
DOE	Department of Energy
EE	energy efficiency
ET	emerging technology
EEV	electronic expansion valve
EU	evaporator unit
EVT	Efficiency Vermont
GHG	greenhouse gas
GWP	global warming potential
HECU	high-efficiency condensing units
HEEU	high-efficiency evaporator units
HFC	hydrofluorocarbon
HFO	hydrofluoroolefin
HP	horsepower
HTR	hard-to-reach

Acronym	Meaning
HVAC	heating, ventilation, and air conditioning
IAPMO	International Association of Plumbing and Mechanical Officials
IMC	Incremental measure cost
IOU	investor-owned utility
kWh	kilowatt-hour
Low-GWP	low global warming potential
MAT	measure application type
NC	new construction
NMEC	net metering energy consumption
NR	normal replacement
OEM	original equipment manufacturer
PA	program administrator
PG&E	Pacific Gas & Electric
RSG	Refrigerated Solutions Group
QPL	qualified product list
RC	remote condenser
RMP	refrigerant management program
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
TPM	technology priority map
TRM	technical reference manual
UMC	Uniform Mechanical Code
WICF	walk-in coolers and freezers

Acronym	Meaning
Wh	watt-hour
WH	water heating
VEIC	Vermont Energy Investment Corporation
VS	variable speed

Introduction

This Focused Pilot project was intended to identify and address the barriers associated with the purchase and installation of commercial high-efficiency condensing units (HECUs) and high-efficiency evaporator units (HEEUs) employed in walk-in coolers and freezers and remote condensing refrigerated cases, which are commonly used by food retail customers and restaurants. The pilot team worked with HECU and HEEU manufacturers, distributors, and operators to prepare a comprehensive market characterization study, test two potential midstream incentive program designs, and perform on-site equipment testing and energy analysis to develop and present a series of program implementation recommendations and to compile all data points needed to prepare a measure package for these measures.

Stakeholder Engagement

The program engaged a variety of stakeholders to support pilot feedback, design, implementation, and other coordination. Stakeholders included energy-efficiency program implementers; professional organizations that support the refrigeration industry, such as the North American Sustainable Refrigerant Council; equipment manufacturers; equipment distributors; refrigeration contractors; and end users.

Background

Business Case

Modular commercial refrigeration is prevalent across multiple business types throughout California. Commercial foodservice facilities, institutional kitchens, convenience stores, and small grocery stores rely on condensing units and evaporators to maintain safe and reliable temperatures in walk-in coolers and freezers. With approximately 68,000 restaurants, 12,000 convenience stores, and 4,700 grocery stores in California, the market size for high-efficiency condensing units and evaporators is massive. These technologies currently have low market penetration due to higher first cost and lack of energy-efficiency programs and technology-specific incentives.

The savings potential per unit is also significant for HECUs and HEEUs, with an average gross annual savings per unit of 3,200 kWh and 0.6 kW peak demand reduction per condensing unit and 2,100 kWh and 0.24 kW peak demand reduction per evaporator, according to the Vermont eTRM. In discussion with Heatcraft, a major manufacturer of these technologies, it emerged that lack of targeted efficiency programs and contractor education are the primary barriers to market adoption. As such, the project team pursued tasks to test program design and contractor education. Both Heatcraft and VEIC stated that incentivizing HECUs and HEEUs would help facilitate low-GWP refrigerant adoption in new high-efficiency product lines. Combined, energy savings, GHG emissions reduction from low-GWP refrigerants, and large market size give high-efficiency condensing units and evaporators the potential for significant California IOU energy-efficiency portfolio impacts.

Focused Pilot Project Scope

The HECU HEEU Focused Pilot Program sought to overcome barriers to the widespread use of high-efficiency remote condensing and evaporator units in commercial foodservice. Those barriers include market awareness of the benefits of these high-efficiency technologies, contractor familiarity with the equipment, higher equipment purchase costs, lack of laboratory and field-testing data to support a measure package, and little understanding among program implementation and utility staff regarding equipment sales and distribution channels and customer purchasing habits.
To address these barriers[1], the project included six main components:

1. Market characterization study
2. On-site equipment monitoring
3. Midstream incentives pilot
4. Qualified products list
5. Equipment energy regression modeling
6. Measure package development preparation

Market Characterization Study

The market characterization study (Section 1. HECU and HEEU Market Characterization Study*)* collected information on the equipment, sales and distribution, and customers associated with cooler and freezer refrigeration in the foodservice space. The team collected information by interviewing market actors, reviewing existing research and literature reviews, and analyzing available products and incentive program offerings in other states. The study includes findings on the following:

- Key market actors and dominant channels for equipment sales and distribution.
- Existing and in-development standards such as federal appliance standards and ASHRAE standards applicable to the technology.
- Minimum efficiency requirements that provide savings above code.
- Characteristics and habits of the customers who purchase this equipment and barriers to specifying and purchasing high-efficiency models in customer facilities. Similarities and differences of barriers within customer segments, with particular emphasis on identifying differing barriers for hard-to-reach (HTR) customers, disadvantaged communities (DAC) customers, and national chain account customers.
- Determination of what equipment is currently being sold in the state, including penetration of high-efficiency units, most common brands, manufacturers, models, and pricing.
- Key findings and gaps from existing research and testing done on this equipment.
- Characterization of the features that define high-efficiency and low-GHG-emitting products, such as low-GWP refrigerants, variable speed condenser fans, high-efficiency

[1] See Appendix A for blueprint of how pilot components address identified barriers

compressors, electronic expansion valves, floating head pressure controls, evaporator fan controls, high-efficiency fan motors, and smart defrost controls.

On-Site Equipment Monitoring

The project team conducted on-site equipment monitoring (Section 2. On-site Monitoring Pilot Program) for 10 projects to obtain data on field operation to be used to understand and quantify energy and GHG emission savings resulting from equipment installations. Projects selected for monitoring were representative of the key customer types and climate zones for this type of equipment in California.

The pilot team installed on-site monitoring equipment and collected data pre- and post-installation for baseline and new equipment. The team recruited sites and ensured a customer agreement was in place with each selected project. Sites were responsible for selecting contractors, installing HECUs and HEEUs, and following all applicable licensing and permitting requirements.

When available, data from facility energy management systems (EMS) was collected and used. Primary data collected included refrigerant type, ambient dry bulb temperature, voltage, amperage, measured kW, and operating hours. In exchange for permission to conduct on-site monitoring, EMS data sharing, interviews with key contacts, and access to participating businesses during operating hours, the project reimbursed customers for the full cost of equipment and installation, up to $15,000 per project.

Site monitoring followed the California Monitoring and Evaluation Protocol (State of California Public Utilities Commission. 2006) set by the CPUC. When available, the pilot team conducted surveys or interviews of customers and installing contractors to document purchasing habits, project barriers, satisfaction with equipment, and energy- and GHG-saving features of the new efficient equipment.

Midstream Incentives Pilot

The pilot team conducted a midstream incentives pilot (Section 3. Midstream Incentives Pilot Program*)* to test the effectiveness of midstream incentives in promoting the stocking and sales of high-efficiency condensers and evaporators. Our pilot design included the following:

- Incentives to equipment distributors in two treatment groups: (1) A point-of-sale model where incentives must be passed through to customers and distributors are provided per-unit incentive (spiff) for providing the customer incentive as a reduction on a customer or contractor’s sales invoice. (2) A traditional midstream incentive that is paid to distributors and does not require pass-through to customer.
- Incentive amounts based on information gathered in the market characterization study and estimated incremental measure cost (IMC).
- Educational and marketing materials for distributors and contractors on high-efficiency equipment, upselling techniques, stocking practices, and end-user benefits.
- A survey of participating distributors to obtain feedback on pilot design and effectiveness.

Qualified Products List

A qualified products list (QPL) (Section 4. Qualified Products List) of high-efficiency condensing units and high-efficiency evaporator units was required for the implementation of the midstream incentive pilot program and reference in any future program. The market characterization study provided equipment components required to define high-efficiency condensing units and high-efficiency evaporators as measures. For the midstream incentives pilot, the team built a QPL of product models that meet the feature requirements identified in the market characterization study.

Equipment Energy Regression Modeling

The pilot team performed regression modeling on the site monitoring data to normalize and aggregate the results. The initial scope of the project involved baseline simulation modeling if needed, but it was not necessary; the site monitoring data was robust enough. The initial scope also involved normalizing monitoring data across all 16 California climate zones. This was also determined to be unnecessary for the Focused Pilot, as climate zone modeling is dependent on measure package savings methodology. This project did not include measure package development and since climate zone modeling may not be relevant to the methodology chosen for future measure package development, the team did not pursue climate zone modeling.

Data Compilation in Preparation of Measure Package Development

Monitored and normalized data collected from site monitoring is included for transfer to another party to prepare a measure package for submittal to the California Technical Forum (CalTF) (Appendix J: Site Monitoring Summary Data). An approved measure package would be required to enable programs to offer incentives for this equipment in California. Collected data confirms viable energy and GHG emissions savings and Measure Package Development is the recommended next step.

Focused Pilot Deliverables

The Focused Pilot has six key deliverables and associated deadlines:

1. Project Plan
    a. The Project plan outlined the project, scope of work, and budget for this Focused Pilot.
    b. The Project Plan was submitted to SCE on December 8, 2022, and was accepted by SCE after comment and revisions on December 26, 2022.
2. Preliminary Findings Report
    a. The Preliminary Findings Report documented initial findings as well as the market characterization study and qualified products list (scope items #1 and #4 in this report).
    b. The Preliminary Finding Report was submitted to SCE on March 30, 2023, and accepted on May 9, 2023.
3. Draft Report
4. The Draft Report includes results, data, and analysis from on-site data collection, midstream pilot design, energy performance simulation modeling, and data compilation in support of

measure package development (scope items #2, 3, 5, and 6 above). Our Draft Report includes summary recommendations for measure package development and program implementation.

    a. The Draft Report was submitted for review to SCE on August 14, 2024, and accepted on September 4, 2024.

5. Final Report
    a. The Final Report (this document) incorporates feedback from the client and stakeholders based on the findings reported in the Draft Report. The final report also includes any updated data, observations, or calculations that are outstanding or still in process at the time of Draft Report submittal.
    b. The Final Report was submitted for review to SCE on September 24, 2024, and accepted on October 14, 2024.
6. Distribution Report
    a. The Distribution Report will share the approach and activities to distribute the information gained during the project.
    b. The Distribution Report delivery date is expected to be October 28, 2024.
7. Performance Metrics Report
    a. The Performance Metrics Report will document completion and distribution of the Final Report and adherence to the project plan timeline of all Focused Pilot deliverables.
    b. The Performance Metrics Report delivery date is expected to be November 11, 2024.

Focused Pilot Partners and Roles

Energy Solutions' roles in the Focused Pilot included oversight of all project components and deliverables, project administration, and coordination among partners. Energy Solutions developed the qualified products list and implemented the midstream incentives pilot.

VEIC contributed to the market characterization study by leading the refrigerant portion of the characterization, supporting the characterization with information from their implementation and research experience, interviewing market actors, identifying potential sites for low-GWP refrigerant monitoring, and analyzing energy- and GHG-emissions impacts. VEIC also contributed to contractor training and quality control throughout the project.

TRC contributed to the market characterization study, participated in site recruiting and establishment of data collection protocols, conducted on-site monitoring of selected projects, and developed education and marketing materials.

AESC has been involved in site recruiting, drafting measurement and verification protocols, and conducting on-site monitoring of selected projects.

The Ortiz Group's participation included site recruiting, developing, and implementing a customer purchasing habits study, and providing consultation on identification of HTR and DAC barriers, focused marketing, and including HTR and DAC customers in the on-site monitoring project selection.

Frontier Energy's participation has included energy regression modeling, compiling data for California measure package development, and reviewing and contributing to quality control throughout the project as subject matter expert for the foodservice market.

Section 1. HECU and HEEU Market Characterization Study

Introduction

As part of this Focused Pilot project, the market characterization study investigates California market dynamics and identifies opportunities around HECU and HEEU equipment uptake. It outlines market prospects, key market actors, the supply chain ecosystem, and barriers to adoption of high-efficiency condensing units and evaporators.

For this study, the market encompasses refrigeration systems serving remote condensing refrigerated cases and remote condensing walk-in coolers and freezers (WICF) in equipment retrofit, end-of-useful life replacement, and new construction applications. The end-use equipment is not limited to refrigerated cases and WICF. Rather, it is defined by any refrigerated space typically served by remote condensing units (CUs), with the most common applications being cases and walk-ins.

Technology Overview

Define Efficiency Measures

This section defines the efficiency measures associated with HECU and HEEU technology, providing context for the components that make up each type of equipment. This information cascades into detailed descriptions of standard- and high-efficiency systems, including performance and expected characteristics. The section concludes with potential measure applications of the HECU and HEEU technology in IOU incentive programs.

EQUIPMENT COMPONENT MAKE UP

Remote condensing units paired with evaporator units comprise the main components of direct expansion, vapor compression, and split refrigeration systems. These systems typically serve remote condensing cases and walk-ins for low- and medium-temperature refrigeration loads. Unlike self-contained systems which are shipped fully charged with refrigerants, remote systems are shipped "dry" and refrigerant piping must be installed by a refrigeration contractor. The contractor must also charge the system with refrigerant upon start-up.

There are four primary components within a typical refrigeration cycle:

1. Compressor
2. Condensing coil
3. Expansion valve
4. Evaporator coil

Components (1) and (2) are combined as a single piece of equipment, which is commonly referred to as a "condensing unit." Components (3) and (4) are also combined and commonly referred to together as an "evaporator unit" or "unit cooler." The condensing unit is located outside of the refrigerated space and the evaporator unit is located inside of the refrigerated space.

The condensing unit is the high-pressure, heat-rejection side of the refrigeration system. It typically consists of one or more refrigerant compressors, a refrigerant condensing unit heat exchanger (condensing coil), condensing unit fans and motors, and factory-supplied accessories such as a refrigerant receiver-dryer, accumulator, and control components. It can be installed indoors or outdoors and is located immediately adjacent to or remotely from the refrigerated load served. The primary role of the compressor is to pressurize the refrigerant, i.e., vapor compression, and move it throughout the refrigeration circuit. The hot, high-pressure refrigerant exiting the compressor passes through the condensing unit coil, where it transfers heat to the ambient environment and is cooled and condensed into a high-pressure liquid that is then routed to the evaporator. The condensing unit is connected to the evaporator unit by refrigerant piping comprising a high-pressure liquid line and a low-pressure gas suction line.

The evaporator unit serves the low-pressure, heat-absorption side of the refrigeration system. The evaporator and its components are installed within the refrigerated space. They include an expansion valve, a refrigerant evaporator heat exchanger (evaporator coil), evaporator fans and motors, and factory-supplied accessories. The role of the expansion valve is to throttle the liquid refrigerant distributed through the evaporator heat exchanger coil. As the liquid refrigerant moves through the evaporator’s heat exchanger, it changes phase or “boils” and expands into gas, i.e., direct expansion, absorbing heat from the refrigerated space. This study focuses on evaporators installed in walk-in applications.

To meet design requirements, the replacement of one component within the refrigeration system must consider the capacity and performance of the other components. For the simplest systems, the design is reduced to selecting one condensing unit and one evaporator unit. It is not uncommon for the units to be designed as one system and installed together based on end use, i.e., cooler vs. freezer, and volume of the refrigerated space, but they do not need to be installed or replaced at the same time and can be manufactured by different companies. However, the controls for the two units must be compatible, and the units must use the same refrigerant.

In remote refrigeration systems, there is typically one condensing unit connected to one or more evaporator units. Together they serve a single refrigeration load and/or temperature application. Sizes for this class of equipment typically range from 4,000 to 150,000 Btu (0.5 to 10 HP, dependent on temperature and efficiency) and are most used in food retail and restaurants including grocery stores, supermarkets, independent markets, convenience stores, fast-food, full-service restaurants, hospitals, schools, institutional cafeterias, farms, and farm stands. These are the units included in this study.

Larger options are available for specialty applications (in the range of 10 to 25 HP). For these larger refrigeration loads, the systems installed are more commonly multiple compressor refrigeration rack systems. Some units can serve pull-down temperature for blast chilling and freezing applications. Larger units above 10 HP and specialty cooling applications are not included in this study.

STANDARD SYSTEMS

The *standard* refrigeration system is defined as what the end user would implement absent program involvement. This is expected to be driven by application, market availability, and regulatory requirements related to the system. Standard-efficiency condensing units and evaporators are systems designed to meet or slightly exceed code minimum requirements set forth by federal and state codes and regulations. High-efficiency units increase the heat rejection capacity while maintaining the lowest possible electrical energy consumption. At present, there is no universal testing method or standardized energy metric to measure the efficiency of individual condensing units, evaporators, or paired systems; the excerpts from the Code of Federal Regulations (CFR) below pertain to condensing unit and evaporator efficiency.

CFR Title 10, Chapter 2, Subchapter D, Part 431.63(c)

> *(c) AHRI. Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, (703) 524–8800, ahri@ahrinet.org, or http://www.ahrinet.org/Content/StandardsProgram_20.aspx.*
>
>> *(1) ARI Standard 1200–2006,* **Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets**, *2006, IBR approved for §§ 431.64 and 431.66, and appendices A and B to subpart C of part 431.*
>>
>> *(2) AHRI Standard 1200 (I–P)–2010 ("AHRI Standard 1200 (I–P)–2010"),* **2010 Standard for Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets**, *2010, IBR approved for §§ 431.64 and 431.66, and appendices A and B to subpart C of part 431.*
>
> *(d)* **ASHRAE.** *The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1971 Tullie Circle NE., Atlanta, GA 30329, or http://www.ashrae.org/.*
>
>> *(1) ANSI/ASHRAE Standard 72–2005, (ASHRAE 72–2005), "Method of Testing Commercial Refrigerators and Freezers," Copyright 2005, IBR approved for § 431.62, and appendices A and B to subpart C of part 431.*

CFR Appendix C to Subpart R, Part 431

> *Appendix C to Subpart R of Part 431 - Uniform Test Method for the Measurement of Net Capacity and AWEF of Walk-In Cooler and Walk-In Freezer Refrigeration Systems*
>
>> *1.0 Scope*
>>
>>> *This appendix covers the test requirements used to determine the net capacity and the AWEF of the refrigeration system of a walk-in cooler or walk-in freezer.*
>>
>> *2.0 Definitions*
>>
>>> *The definitions contained in § 431.302 and AHRI 1250–2009 (incorporated by reference; see § 431.303) apply to this appendix. When definitions in standards incorporated by reference are in conflict or when they conflict with this section, the hierarchy of precedence shall be in the following order: § 431.302, AHRI 1250–*

> *2009, and then either AHRI 420–2008 (incorporated by reference; see § 431.303) for unit coolers or ASHRAE 23.1–2010 (incorporated by reference; see § 431.303) for dedicated condensing units.*

> *3.0 Test Methods, Measurements, and Calculations*

> *Determine the Annual Walk-in Energy Factor (AWEF) and net capacity of walk-in cooler and walk-in freezer refrigeration systems by conducting the test procedure set forth in AHRI 1250–2009 (incorporated by reference; see § 431.303), with the modifications to that test procedure provided in this section. When standards that are incorporated by reference are in conflict or when they conflict with this section, the hierarchy of precedence shall be in the following order: § 431.302, AHRI 1250–2009, and then either AHRI 420–2008 (incorporated by reference; see § 431.303) or ASHRAE 23.1–2010 (incorporated by reference; see § 431.303).*

The annual walk-in energy factor (AWEF) rating is a newer regulatory efficiency metric recently implemented by the Department of Energy (DOE) to measure electrical energy input vs. a system's cooling capacity. Many of the larger manufacturers have adopted the AWEF rating, but it is not consistently applied, verified, or enforced.

Manufacturers have different strategies for improving the energy efficiency of their systems. They may use custom designs and proprietary controls to optimize energy use, including specific efficiency components, materials selection, system configurations, equipment sizes, and integrated and adaptive controls algorithms. It is difficult to quantify how much each of the individual components within these systems contributes to its overall efficiency. As a result, this market characterization study evaluates the interactive effects of the whole system.

Review and Summary of Federal and State Codes and Standards

For commercial refrigeration systems, manufacturers and contractors must simultaneously comply with federal government and State of California codes and standards, at a minimum. For the purposes of this market characterization, those code minimums are considered the baseline. High-efficiency technologies evaluated in this study are those with incremental increases in efficiency based on certain equipment features. To characterize the baseline, the team reviewed the following:

- The Code of Federal Regulations (CFR)
- Title 20 California Appliance Efficiency Regulations (Title 20)
- Title 24 California Building Energy Efficiency Standards (Title 24)

Code of Federal Regulations (CFR)

Commercial refrigeration products sold within the United States must comply with the following sections of Title 10 of the Code of Federal Regulations:

- Part 431, Subpart C, Commercial Refrigerators, Freezers and Refrigerator-Freezers (sets energy conservation requirements)

- Part 431, Subpart R, Walk-in Coolers and Walk-in Freezers (sets energy conservation requirements)
- Part 429, Subpart B, §429.42 Commercial refrigerators, freezers, and refrigerator-freezers (outlines testing procedures)

Current Federal manufacturing standards dictate that commercial walk-in refrigerators and freezer units manufactured after January 1, 2009, shall use (CFR, Title 10, 431.306(a)(5-6)):

- Electronically commutated motors (brushless direct current motors) or three-phase motors for evaporator fan motors under 1 horsepower
- Electronically commutated motors (brushless direct current motors), permanent split-capacitor motors, or three-phase motors for condensing units under 1 horsepower

State of California Regulations

TITLE 20

California Title 20 has published system performance requirements for various appliance system configurations and end uses. If the measure is considered new construction, then the cumulative performance of the equipment shall minimally comply with the performance metrics published within the federal and state standards for federally regulated appliances within Title 20. Table 1, Table 2, and Table 3 detail performance requirements for walk-in coolers and freezers, which are expected to be the most common application of the HECU and HEEU technology.

Walk-in Coolers and Freezers

Table 1: Performance Standards for Walk-in Cooler and Walk-in Freezer Refrigeration Systems Manufactured on or After January 1, 2020 (Title 20, Section 1605.1(a)5(F), Table A-12)

Class Descriptor	Minimum AWEF[2] (Btu/Wh)
Dedicated condensing, medium-temperature, indoor system	5.61
Dedicated condensing, medium-temperature, outdoor system	7.60

HECUs can also operate as remote condensers (RC) for various commercial refrigeration equipment. Table 2 below presents the Title 20 requirements for the refrigeration equipment families that use a remote condensing unit.

[2] Annual walk-in energy factor.

Commercial Refrigerators and Freezers with Remote Condensing Units

Table 2: Performance Standards for Commercial Refrigerators and Freezers with Non-Hybrid Remote Condensing Units (Title 20, Section 1605.1(a)2(A), Table A-4.)

Equipment Family	Rating Temperature (°F)	Operating Temperature (°F)	Equipment Class Designation*	Maximum Daily Energy Consumption (kWh)
Vertical open (VOP)	38 (M) 0 (L)	≥ 32 < 32	VOP, RC, M VOP, RC, L	0.64 × TDA[3]+ 4.07 2.20 × TDA + 6.85
Semivertical open (SVO)	38 (M) 0 (L)	≥ 32 < 32	SVO, RC, M SVO, RC, L	0..66 × TDA + 3.18 2.20 × TDA + 6.85
Horizontal open (HZO)	38 (M) 0 (L)	≥ 32 < 32	HZO, RC, M HZO, RC, L	0.35 × TDA + 2.88 0.55 × TDA + 6.88
Vertical closed transparent (VCT)	38 (M) 0 (L)	≥ 32 < 32	VCT, RC, M VCT, RC, L	0.15 × TDA + 1.95 0.49 × TDA + 2.61
Horizontal closed transparent (HCT)	38 (M) 0 (L)	≥ 32 < 32	HCT, RC, M HCT, RC, L	0.16 × TDA + 0.13 0.34 × TDA + 0.26
Vertical closed solid (VCS)	38 (M) 0 (L)	≥ 32 < 32	VCS, RC, M VCS, RC, L	0.10 × V + 0.26 0.21 × V + 0.54

Along with system performance, Title 20 requires specific motor types for walk-in coolers and freezers installed after 2008.

Table 3: Title 20 Motor Type Requirements for Evaporators and Condensing Units (Title 20, Section 1605.1(a)4E–F)

Equipment	Requirement
Evaporator fan motor < 1 HP	Electronically commutated motor or three-phase motor
Condensing unit fan motor < 1 HP	Electronically commutated motor; permanent split capacitor motor; or three-phase motor

[3] Total Display Area.

Finally, for food retail and beverage stores that are less than 8,000 square feet, California's Title 20 appliance efficiency regulations apply. This is likely to include systems found in convenience stores, quick-service restaurants, and cafes. Title 20 section 1605.1(a) covering commercial refrigeration appliances refers to the federal standards as a guide. There are no additional efficiency requirements specific to condensing units and evaporators reflected in Title 20 regulations.

TITLE 24

In addition to the CFR and Title 20 requirements, commercial refrigeration systems in California must comply with California's Title 24 Building Energy Efficiency Standards Section 120.6: Mandatory Requirements for Covered Processes. Condensing units within the scope of this market characterization are exempted from Title 24, Part 6 through Exception 1 of Section 120.6(b)1G:

> *Condensing units with a Total Heat Rejection capacity of less than 150,000 Btuh at the specified rating condition.*

High-Efficiency Systems in Commercial Refrigeration

Going beyond code minimums, many manufacturers add features and components to their condensing units and evaporators that incrementally increase system efficiency and provide greater operational control. A combination of those features can deliver significant energy savings over the baseline and allows a system to be classified as "high-efficiency."

High-Efficiency Condensing Units (HECUs)

The efficiency measures listed below are not required by code and should be individually considered for inclusion as part of an HECU incentive program. These efficiency measures are not specific to a particular manufacturer. An HECU may not be required to have all the efficiency measures included in this list.

HECU EFFICIENCY MEASURES

- Variable speed compressor capacity capabilities (modulating compressor, external VFD, or scroll compressor)
- Efficient heat exchanger technology and/or oversized heat exchangers
- Variable speed and/or fully modulating condensing unit fan motor controls
- Floating head pressure controls

Variable Speed Compressors

Compressors keep a system's refrigerant both pressurized and flowing. They are also the system's biggest energy consumers. When cooling demand is lower, a variable speed compressor adapts, decreasing its speed to save energy. Variable speed capability must be enabled through the unit's control system interface. Another advantage is that stop/start cycles are minimized, which prolongs compressor motor life.

Scroll Compressors

Scroll compressors are an acceptable alternative to variable speed compressors since they tend to display similar efficiency at various levels of loading. Scroll compressors are a type of positive displacement compressor having several advantages over reciprocating or other traditional compressor types, including higher operating efficiencies and lower noise levels.

Efficient Heat Exchanger

A unit's heat exchanger can use design elements that are more efficient than those in standard units. An efficient heat exchanger maximizes surface area for heat rejection to the environment, and may use a microchannel, plate-and-frame, or fin tube design. Heat rejection surface area can be expanded even more by choosing the largest cabinet size available for the specified compressor. A more-efficient heat exchanger will increase heat rejection capacity and result in lower energy demand.

Modulating Condensing Unit Fan Motors

Adaptive fan controls allow the modulation of the condensing unit fan motor(s) to meet demand based on a setpoint of the refrigerant gas and ambient air temperature. This in turn maintains system head pressure (see next section) while reducing fan energy. Different control sequences and fan cycling methods can be used if the condensing unit fans automatically reduce speed when the refrigerant gas temperature exceeds the setpoint temperature. Temperature setpoints should be programmed using the unit's control system interface.

Floating Head Pressure Controls

Floating the head pressure of a system means that the pressure generated by the compressor is allowed to decrease or "float" within a range set in the control system as temperatures at the condensing unit decrease. This reduces the work needed from the compressor and increases its efficiency. Some manufacturers float the head pressure by changing the condensing unit fan motors' operation, while other manufacturers use different control points.

To float the head pressure for energy efficiency, the condensing unit must be installed outdoors where temperatures fluctuate seasonally. The user must set modulating fan motor speed and floating head pressure controls once the system is installed to take advantage of colder ambient temperatures.

High-Efficiency Evaporator Units (HEEUs)

The federal and state energy code requirements described previously set the minimum efficiency requirements for all new evaporators. The individual efficiency measures listed below are not required by code and may be considered for inclusion as part of an HEEU incentive program.

These efficiency measures are not specific to a particular manufacturer. An HEEU may not have all the efficiency measures included in this list.

HEEU EFFICIENCY MEASURES

- Electronic expansion valve (EEV)
- Variable speed and/or fully modulating evaporator fan motor controls
- Advanced defrost controls

Electronic Expansion Valve (EEV)

An expansion valve regulates the flow of liquid refrigerant into the evaporator heat exchanger. The EEV allows precise tuning based on refrigerant pressure and temperature as measured by electronic sensors located at the evaporator outlet (suction line) using the unit's control system interface.

With an EEV, superheat can be more finely tuned and decreased further than it can with other types of expansion valves. This reduces unnecessary refrigerant flow and therefore saves energy.

Modulating Fan Motor Controls

Adaptive fan controls allow modulation of the evaporator fans' motors to meet demand based on a temperature setpoint of the refrigerated space. Different control sequences and fan cycling methods can be used for evaporator fans to automatically reduce speed when refrigerated space's temperature setpoint has been met. Temperature setpoints should be programmed using the unit's control system interface.

Advanced Defrost Controls

Evaporator heat exchangers in low-temperature applications need to be defrosted periodically to prevent ice build-up on the coils. Adaptive, smart, or on-demand defrost controls allow the system to shorten or skip defrost cycles when no ice is detected. The baseline consists of pre-scheduled cycles that automatically turn on the defrost heating element. Smart controls adjust defrost cycles based on evaporator performance to prevent unnecessary energy demand on the system and reduce heat from being added to the refrigerated space. Defrost controls are typically only used in low-temperature applications where added heat is used to defrost the evaporator coils. Medium temperature units cycle off the mechanical systems and use ambient heat to defrost the coils.

Summarized System Characteristics of HECUs and HEEUs

Table 4: System Characteristics of HECUs and HEEUs

Energy-Efficiency Characteristic	Description
Variable speed condenser fan	Variable speed condenser fans can reduce fan speed while maintaining the same level of condenser coil heat transfer. Control logic is based on the expected coil temperature and outdoor conditions.
Variable speed compressor	Variable speed compressors allow the system to efficiently maintain a targeted head pressure at a wide range of loading. Should be considered with controls that impact refrigerant flow or head requirements.
Scroll compressor	Scroll compressors are an acceptable alternative to variable speed compressors since they can modulate and display similar efficiency at various levels of loading.
Floating head pressure controls	Floating head pressure controls allow the system to reduce the head requirements on the compressor during periods where the condensing is anticipated to have excessive coil capacity. The control is expected to increase the consumption of the condensing unit fan and decrease the consumption of the compressor. The net impact is anticipated to result in energy savings. Pair with variable speed compressor for enhanced savings.
Electronically commutated motors (ECM) for fans	ECMs are high-efficiency motors that result in savings over conventional, single speed permanent split capacitor and shaded pole motors.
Electronic expansion valve	Electronic expansion valves are used to control the amount of refrigerant passing through the evaporator. Controlling the valve based on a superheat feedback loop minimizes the amount of excessive superheating. Pair with variable speed compressor for enhanced savings.
Advanced defrost controls	Controls that manage the defrosting interval to minimize adding heat to the refrigerated space. The controllers range widely in complexity, from simple local sensor feedback loops to machine learning algorithms.

HECUs and HEEUs are expected to have the energy-efficient characteristics shown in Table 5 below. While there is no strict definition of efficiency characteristics that constitute an HECU or HEEU, the right column shows the project team's judgement of whether a characteristic is required or optional in terms of whether it would be considered efficient (i.e., would meet the study team's definition of an HECU or HEEU).

Table 5: Proposed Energy-Efficiency Characteristics for HECUs and HEEUs

Equipment	Characteristics	Required to be Considered HECU/HEEU
HECU	Variable speed compressor or scroll compressor	Required
HECU	Variable speed condenser fan	Required
HECU	Floating head pressure controls	Required
HEEU	Electronically commutated motor	Required
HEEU	Variable speed fan controls	Required
HEEU	Electronic expansion valve	Tier 2 Requirement
HEEU	Advanced defrost controls	Tier 2 Requirement

Key Market Attributes

As explored in the previous section, the individual components of the equipment have been studied at length, i.e., scroll compressor, evaporator motor controls, floating head pressure controls. However, no studies have evaluated packaging all these high-efficiency components into a single condensing unit measure or a single evaporator measure. An integrated design has additional efficiency benefits when the system is evaluated as a whole and the interactive effects of the individual components considered.

Gaps also exist within the characterization of the commercial refrigeration market in California. Instead of evaluating the potential of these measures for their bottom-up, measure-based potential savings approach, the 2021 California Potentials and Goals Study[4] heavily leveraged market data from the U.S. Northwest.

Prepared for the CPUC in 2014, the California Commercial Saturation Survey (Itron, Inc. 2014) gave the best characterization of the commercial refrigeration market in the state but was not comprehensive. In addition, this information may be out of date given the raw data for the study dates to 2012 and 2013. In the potential technical assessment for HECUs and HEEUs conducted later in this report, some of the equipment splits from this report were used.

[4] The 2021 California Potentials and Goals Study is the most recent iteration of a statewide potential study coordinated by the CPUC and engineered by Guidehouse. The study leveraged a measure-based, bottom-up approach to quantifying technical, economic, and achievable potential. While the study did use California building stock data, the Northwest Energy Efficiency Alliance 2014 Commercial Building Stock Assessment was used for the market characterization of commercial refrigeration measures (i.e., measure density, baseline saturation, efficient equipment penetration). This highlights the gap in market data available for commercial refrigeration measure characterization, as the state's own potential study leveraged data from Washington, Oregon, Idaho, and Montana. The savings estimates, however, were sourced directly from California-specific DEER workpapers.

In addition to these gaps, no measure and verification studies of HECUs and HEEUs have been undertaken. None of the energy-efficiency utility programs offering these measures around the country and benchmarked in this report have undergone an evaluation. Site installation data, verified savings, reconciliation, reproducibility of savings claims, and other key parameters are therefore missing for these measures due to a lack of study and evaluation.

Table 6 below shows key variables for estimating technical potential for efficient commercial refrigeration measures.

Table 6: Market Characterization Estimates on Measure Potential Input Files

Technology	Efficient Saturation Input[5]	Technical Suitability Input[6]
Floating head pressure controls	21.43%	1.00
Efficient compressor (grocery)	40%	1.00
Efficient compressor (other building types)	33.4%	1.00
ECM evaporator fan motor for walk-ins	24.48%	1.00
Efficient refrigerated display case	5%	1.00

Source: 2021 California Potential and Goals Study

Potential Applications for Energy-Efficiency Programs

Potential applications for programs are driven by the incremental benefit over a system's standard design. Standard design for HECU and HEEU will consider the Title 20 and Title 24 requirements, which is grouped by store square footage. In addition to code consideration, the Measure Application Type (MAT) can influence the amount of incremental benefit available per facility. MATs include:

- New construction (NC) measures which use the current standard design as the baseline.
- Normal replacement (NR) measures which use the current standard design as the baseline.
- Accelerated replacement (AR) which allow for existing baselines to be used and can substantially increase the site potential.

[5] Efficient saturation is the penetration of high-efficiency equipment or measures in the market. It is detailed as a percent, indicating what percentage of the units in the market comprise of high-efficiency options.

[6] Technical suitability is the compatibility of a measure within the constraints of the market, installation location, existing infrastructure, etc. In energy efficiency potential studies, it is used as a constraint factor as some measures may not be suitable for every installation location.

- Net metering energy consumption (NMEC) methods that allow for existing baselines to be used and can substantially increase the site potential.

Table 7 and Table 8 below describe the types of applications where HECU and HEEU measures could be applied and the associated energy-efficiency potential.

Table 7: Energy-Efficiency Site Potential for Food Store (<8,000 square feet)

Application	Measure	MAT	Site Potential	Code Consideration
Walk-in cooler Walk-in freezer	HECU HEEU	NC NR AR NMEC	High	Title 20 Requirements for Standard Practice No Title 24 Requirements
Refrigeration with remote condensing unit	HECU	NC NR AR NMEC	High	Title 20 Requirements for Standard Practice No Title 24 Requirements

Table 8: Energy-Efficiency Site Potential for Food Store[7] (>8,000 square feet)

Application	Measure	MAT	Site Potential	Code Consideration
Walk-in cooler Walk-in freezer	HECU HEEU	NC NR	High	Title 20 and Title 24 Requirements for Standard Practice
Walk-in cooler Walk-in freezer	HECU HEEU	AR NMEC	High	Claimable To-Code Potential
Refrigeration with remote condensing unit	HECU	AR NMEC	High	Claimable To-Code Potential

Refrigerants Overview

This market characterization study prioritizes electric-efficiency opportunities associated with HECU and HEEU refrigeration systems and does not cover the full range of refrigerants used in these systems.

Since the phase out of chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants (United Nations. 1987), hydrofluorocarbons (HFCs) have been the dominant refrigerant used in condensing unit condensing units and evaporators. Most of the equipment in operation today,

[7] Retail Food Store is defined as an area within any building that is intended for the display and sale of food.

including many of the efficiency measures evaluated in this study, has been optimized for HFC refrigerants such as R-404A, R-507A, R407A, and R-407C.

In response to changing refrigerant regulations and the HFC phasedown set forward by the American Innovation and Manufacturing Act of 2020, manufacturers of HECU and HEEU equipment are adopting natural and low-GWP refrigerants in their product lines. These new refrigerants, which include hydrofluoroolefins (HFOs), HFC/HFO blends, and natural refrigerants, have different chemical properties and operating characteristics than the traditional HFCs. This requires manufacturers to redesign the traditional systems using new components and control strategies.

Within the last few years, HECU and HEEU manufacturers have widely adopted R-448A and R-449A into their product lines. These refrigerants are considered lower-GWP alternatives and have a GWP value lower than 1,500 (Intergovernmental Panel on Climate Change. 2007). R-448A and R-449A are HFC-HFO blended refrigerants with properties like those of traditional HFCs. This allows HECUs and HEEUs to use a similar system configuration as an HFC system without an energy penalty or a need to change the system components. Refrigerant manufacturers continue to develop ultra-low-GWP refrigerants, defined as refrigerants with a GWP value lower than 10[8]. As these ultra-low-GWP and natural refrigerants have significantly different operating characteristics, new and innovative strategies are required to make refrigeration systems run efficiently.

This study focuses on traditional HECU and HEEU units that use HFC and HFC-HFO blended refrigerants, and on the traditional system designs, components, efficiencies, and operational setpoints. Given the differences in those metrics for ultra-low and natural refrigerant systems, specifically in condensing units, equipment that specifically uses ultra-low-GWP and natural refrigerants was not evaluated as part of this market characterization study.

CalNEXT factors decarbonization impact in its TPM, but it is not an exclusive metric for project submissions. Hence, natural refrigerant condensing units and evaporators should be studied under a separate project within the CalNEXT program.

Supply Chain Characterization

This section identifies supply chain channels and summarizes information obtained through interviews with key market actors within the supply chain. It clarifies how condensing units and evaporators are sold and the existing opportunities to bolster HECUs and HEEUs sales in California.

Overview of the Supply Chain

While California is home to some small local wholesale distributors, six national or international wholesale distribution companies share the evaporator and condensing unit market in the state (Figure 1). Heatcraft (Bohn, Larkin, Climate Control, Chandler), Trenton-Keeprite, and HTPG/Russell offer the greatest variety of qualifying HEEU models. Manufacturers with leading model options for HECUs include Heatcraft (and associated brands), Trenton-Keeprite, Bally, and Emerson.

Key market actors in commercial refrigeration sales include manufacturers, wholesale distributors, contractors, and customers (original equipment manufacturers [OEMs] and commercial end users).

[8] Id.

There are three primary sales channels in the commercial refrigeration condensing unit and evaporator unit market:

- **Wholesale distribution channel.** Manufacturers supply their products to wholesale distributors. Distributors then collaborate with contractors who install equipment for the customers.
- **OEM channel.** Manufacturers sell directly to OEMs. The units are then incorporated into other types of equipment, i.e., a freezer or cooler box, food manufacturing equipment, etc., before being sold to an end user.
- **Direct sales channel.** The end user — often the refrigeration system designer of a major chain — works directly with a manufacturer to specify equipment based on a design plan. The end user then hires their contractor of choice to install.

While direct sales do occur, they primarily take place between the manufacturer and the original equipment manufacturers. Direct sales to larger grocery or warehouse chains with in-house system designers are limited. Wholesale distribution is the most common channel for commercial evaporator units and condensing units.

Commercial refrigeration customers rely on contractors' knowledge to recommend equipment based on their operational needs and existing systems. Contractors then work with distributors to fulfill those needs. While contractors can request certain types of equipment, they tend to rely on what is in stock at the distribution warehouse to avoid delays in project timelines. Wholesale distributors will stock items based on historical demand.

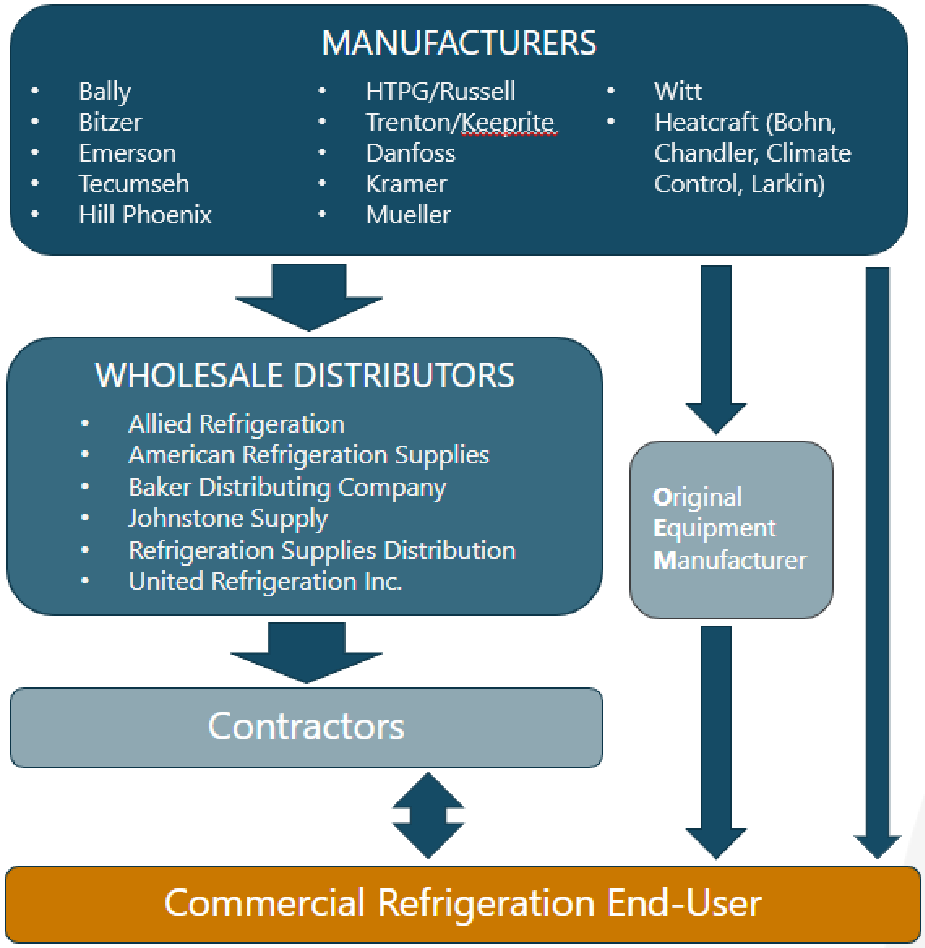

Figure 1: Commercial refrigeration equipment supply chain channels and key market actors

Summary of Market Actor Interviews

Market actor interviews provide important insights into many variables affecting the adoption of high-efficiency features. This study consolidates perspectives from multiple market actors including manufacturers and distributors (this section), as well as program administrators from existing utility programs offering HECU and HEEU measures (see Peer Group Jurisdiction Program Benchmarking section).

Interviews were held with:

- Two technical sales representatives, a business development and key accounts manager, and a western regional sales manager representing three manufacturing companies
- A Southern California regional sales manager and a western regional manager representing two wholesale distribution companies

These five companies represent top manufacturers and distributors in the region. Overall, market actor interviews offer information representative of the entire state except for one primarily focused on the Southern California market.

Table 9: Key Market Actor and Efficiency Program Interviews to Date

Market Actor Interviews	Interviewees	Total Interviews
Manufacturers	Heatcraft	3
	HTPG Russell	
	Trenton/Keeprite	
Distributors	American Refrigeration Supplies	2
	United Refrigeration	
Efficiency Programs	Efficiency Vermont	3
	MassSave	
	DTE Energy	

Equipment Knowledge and Acceptance

The efficiency components of HEEUs and HECUs are no longer brand-new to the market. However, manufacturers are still working to educate both distributors and contractors on the newer components' operational benefits and reliability. When manufacturers offer features like electronic expansion valves (EEVs) or floating head pressure controls, installation contractors may express skepticism regarding the utility and reliability of these features. Manufacturers continue to reach out and offer support to contractors. However, they observe mixed adoption levels attributed to a preference toward well-established technologies. Manufacturers report this sentiment is shifting, albeit slowly, and that OEMs are typically the most enthusiastic adopters. Additionally, electronically controlled systems are becoming more widely accepted by contractors as their knowledge base and exposure to the technology increase. Finally, as many contractors approach retirement, younger installers join the field and typically express greater interest and acceptance of the electronic controls and features.

Stocking Practices

According to interviewed manufacturers, most commercial refrigeration customers rely on contractors' knowledge to recommend equipment fitting their operational needs and existing systems. Contractors then work with distributors to fulfill those needs. However, distributors in California do not typically stock HECUs because demand is low for floating head pressure controls and defrost and scroll compressors. In addition, their costs are significantly higher than contractors and customers are willing to pay. As a result, when a customer does request a system with those features, the distributor must place a special order from the manufacturer, increasing the lead time.

Historically, distributors have rarely kept condensing units with scroll or variable speed compressors in stock unless explicitly requested by key contractors in their locations. However, some compressor manufacturers have begun to shift support away from hermetic compressors to focus primarily on the variable speed (VS) and scroll compressors. This shift will dramatically increase the availability of qualifying HECUs in stock at the distributor level, as scroll and VS compressors are required features for qualifying HECUs.

Stocking practices heavily influence whether a customer will install an HECU or HEEU. Distributors do not typically stock HECUs because of the added costs and the increased complexity of HECU requirements, e.g., multi-component qualification and greater selection of options. Without HECUs readily available, contractors and customers are left to choose a standard efficiency or units with only some of the qualified features for unplanned replacements. In planned retrofit scenarios, the lack of HECU stock creates an additional lead time barrier, even if the timeline for project completion has flexibility. Customers still typically opt for in-stock equipment to reduce the project timeline, especially if the contractor has availability within their schedule to complete work sooner. In new construction projects, distributor stock is less influential to HECU adoption because the timeline can often accommodate longer HECU lead times.

In contrast, HEEUs make up approximately 20 percent of distributor stock. According to distributors, stocking qualified HEEUs is easier that stocking HECUs for the following reasons:

- The demand from contractors and customers warrants stocking them
- The lower incremental cost is not as much a burden
- The simplicity of HEEU qualification makes it easier to select which qualified models to keep in stock

Supply Chain

Both manufacturers and distributors cited long lead times (from 4 to 12 weeks) as a key barrier to adoption for the highest efficiency equipment, most often for HECUs. While mid-pandemic lead times were as high as 6 to 12 *months* for higher efficiency technologies, the peak pandemic lead times have eased and are now around 6 *weeks* for that same equipment. Long lead times result from a combination of delays in component supply chain and manufacturing times. As many of the high-efficiency units are manufactured on the same lines as standard-efficiency units, the latter typically have precedence because they are in higher demand.

Customer Economics

According to multiple manufacturers, the cost is 8 to 15 percent greater for HEEUs and 10 to 20 percent greater for HECUs than for standard efficiency equipment. For both new construction and emergency replacements, the additional up-front cost affects contractor and customer decision-making. Contractors are reluctant to quote a project with higher equipment costs, and customers are often limited by their capital investment budget. According to distributors, customers will most often opt out of high-efficiency models due to budget constraints. Additional indirect costs are also incurred due to the increased lead time associated with efficient equipment special order. While the payback period from energy savings is a key factor, the first costs of new equipment dominate decision-making. According to manufacturers and distributors, equipment costs overall continue to rise, placing additional financial barriers on customers. Where the incremental costs tend to remain the same, rising equipment costs increase the total price differential, making it harder for customers to justify the incremental costs.

Summary of Key Market Barriers Identified

Numerous barriers to widespread adoption of HECUs and HEEUs exist. Manufacturers and distributors most commonly cite:

First costs. Incremental costs for HECUs and HEEUs are the greatest barrier to adoption. Despite long-term energy and cost savings from implementing high-efficiency technologies, the first costs most strongly influence the final customer decision. The financial hurdle disproportionately affects smaller businesses and businesses with unexpected replacement needs.

Lack of stock and supply chain lead times. Distributors often stock a few qualifying HEEU options, but standard efficiency models make up the majority of their stock and qualifying HECUs are not typically kept on shelves. If cost is not the initial deciding factor for a customer, then lack of availability of HECUs and HEEUs can add weeks or months to a project timeline, thus increasing the likelihood that those seeking high-efficiency options will ultimately default to a standard option.

Contractor reluctance and education. Contractor reluctance is a barrier to the adoption of certain features such as EEVs and digital controls. Contractors are reluctant to trust the newer digital components because they perceive them to be a risk to business or do not have experience with their reliability; in some cases, contractors may intentionally bypass efficiency features or may be averse to learning a new system or technology. Manufacturers and distributors believe efforts to educate contractors along with demonstrations of the reliability of these technologies will influence more contractors to offer HECUs and HEEUs.

Measure Availability in California

Common Manufacturers, Brands, and Models

A variety of manufacturers produce qualified high-efficiency condensing units and evaporators that are available to California customers, as shown in Table 10 below.

Table 10: Qualified High-Efficiency Refrigeration Unit Manufacturers, Associated Brands, and Model Options

Manufacturer	Brands	Evaporator Unit Model Option	Condensing Unit Model Option
Bitzer	Bitzer		EcoStar
Danfoss	Danfoss		Optyma Slim
Emerson	Copeland		Scroll X-Line
Heatcraft Refrigeration Products	Bohn Chandler Climate Control Heatcraft Larkin	IntelliGen Quick Response Controller	Orbus
Heat Transfer Products Group (HTPG)	Kramer Russell Witt	Econet	NextGen VS
Mueller	Mueller		E-Star HiPerform
RSG	Master-Bilt Norlake	E1, E2, E3, EM, EV L1, L2, L3	MSL MSV
Tecumseh	Tecumseh		Argus
United Refrigeration	Bally Trenton Keeprite	TLV TPLP TTP	Quiet Unit

Source: CalNEXT and Efficiency Vermont Qualified Products Lists

Refrigerated Solutions Group (RSG) products dominate the HEEU market in terms of the number of options, features, sizes, and model lines available to customers. RSG owns two major brands: Master-Bilt and Norlake. Each offers similar features on qualified products. RSG offerings comprise over 65 percent of the HEEU and over 35 percent of the HECU qualified product options, as shown in Figure 2 and Table 11 below.

Heatcraft Refrigeration products dominate the HECU market in terms of the number of options, features, sizes, and model lines available to customers. Heatcraft owns five brands: Heatcraft, Bohn, Chandler, Climate Control, and Larkin. Each offers qualified products. When combined, Heatcraft offerings comprise over 20 percent of the HEEU and over 55 percent of the HECU qualified product options, as shown in Figure 2 and Table 11 below.

Demand for high-efficiency units should continue to increase due to both rising energy costs and increased incentives available at the state and federal levels. This trend is expected to drive innovation and increase technological diversity of the refrigeration equipment space.

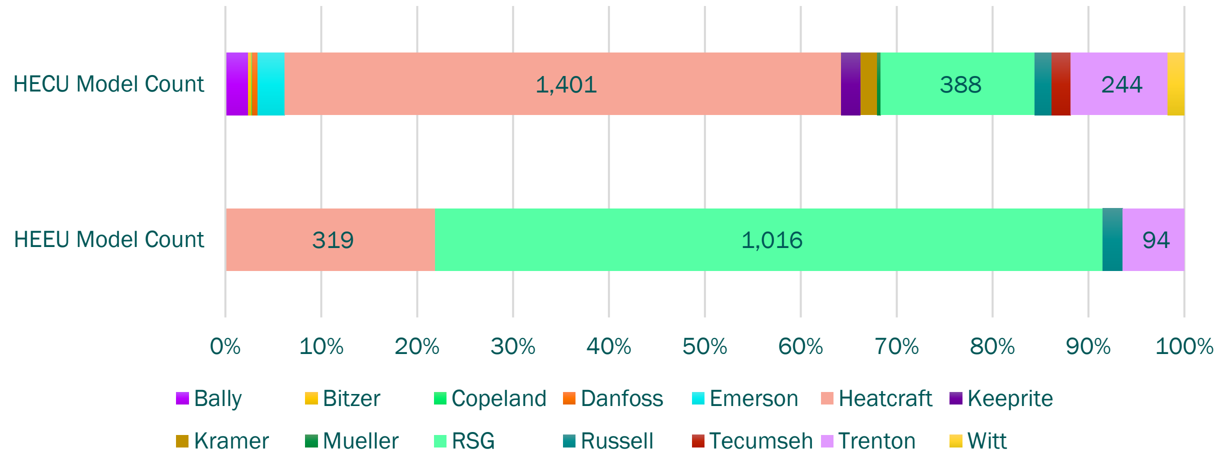

Figure 2: Distribution of qualified high-efficiency refrigeration unit models by manufacturer[9]

Table 11: Count of HEEUs and HECUs by Manufacturer

Manufacturer	HEEU Model Count	HEEU % of QPL	HECU Model Count	HECU % of QPL	Total Count	Total % of QPL
Bally			58	2.4	58	1.5
Bitzer			8	0.3	8	0.2
Copeland			2	0.1	2	0.1
Danfoss			14	0.6	14	0.4
Emerson			67	2.8	67	1.7
Heatcraft	319	22%	1,401	58.1	1,720	44.4
Keeprite			48	2.0	48	1.2

[9] Appendices L and M

Manufacturer	HEEU Model Count	HEEU % of QPL	HECU Model Count	HECU % of QPL	Total Count	Total % of QPL
Kramer			42	1.7	42	1.1
Mueller			9	0.4	9	0.2
RSG	1,016	70%	388	16.1	1,404	36.3
Russell	30	2%	42	1.7	72	1.9
Tecumseh			48	2.0	48	1.2
Trenton	94	6%	244	10.1	338	8.7
Witt			42	1.7	42	1.1
Total	1,459	100%	2,413	100.0	3,872	100.0

Comparison of California Market Potential

To understand the market potential, VEIC examined the composition of commercial refrigeration end users by business type.

Food and beverage retail businesses and restaurants dominate the commercial refrigeration market in California, comprising approximately two-thirds of the market. According to the 2020 Census Bureau's County Business Patterns survey[24], California is home to about 93,000 food and beverage retail and restaurant establishments. The remaining one-third of the refrigeration market includes schools, hospitals, offices, and other locations where commercial refrigeration systems are used but where refrigeration is not a primary function of their business model. The business types and number of establishments in California are shown in Table 12.

Table 12: Total Number of Establishments in California and as Percent of National Total by Business Type

Business Type	Number of Establishments in California	California as % of National Total
Convenience stores	2,866	9.2
Gasoline stations with convenience stores	6,446	6.5

Business Type	Number of Establishments in California	California as % of National Total
Supermarkets and other grocery (except convenience) stores	7,733	12.3
Warehouse clubs and supercenters	783	9.6
Restaurant and eating places	75,115	13.0
Other (Hospitals, schools, offices, etc.)	46,472	12.8
Total	139,415	12.2

Source: National and California-Wide County Business Patterns Data, U.S. Census Bureau, 2020

Restaurants and foodservice dominate the commercial refrigeration market with a share of 54 percent compared to 51 percent nationally. California has fewer gasoline stations with convenience stores than the national average (5 percent of the California market compared to 9 percent). All other categories track with national averages.

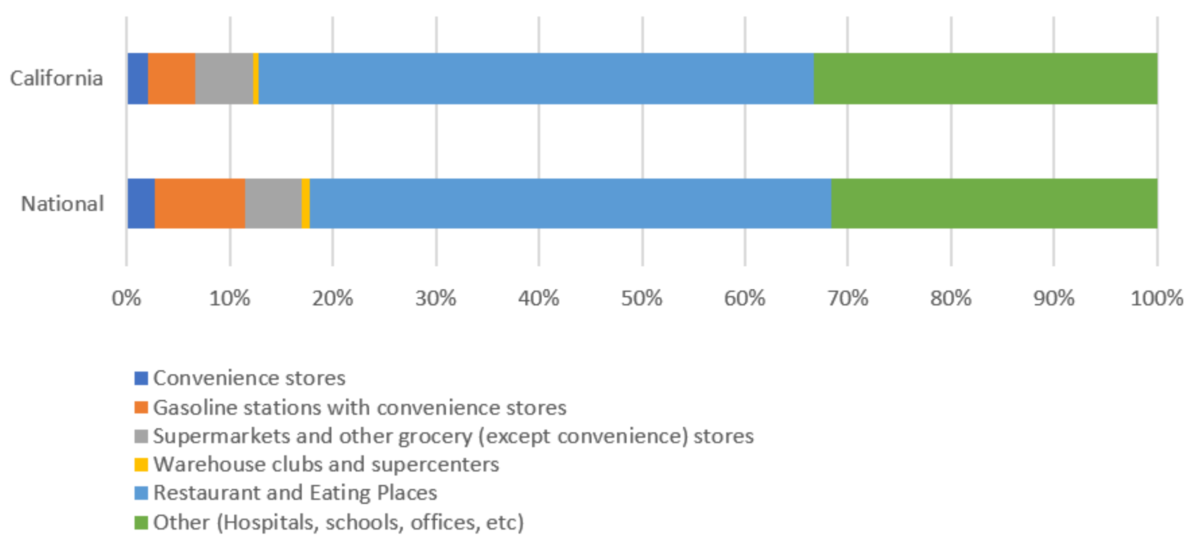

Figure 3: National and California establishments

Source: 2020 U.S. Census Bureau County Business Patterns

Given the correlation between businesses' offerings and their refrigeration needs, the number of evaporators and condensing units varies with the type of services these businesses provide. While most large commercial supermarkets contain refrigeration rack systems tied to refrigerated cases on the retail floor and large roof-top condensing units with multiple fans, these rack systems and condensing units are not included in this study. However, produce and meat processing areas, as well as walk-in coolers and freezers typically use evaporator units and condensing units to meet the cooling load and setpoints. Based on a 2014 Commercial Baseline Study for California (Itron, Inc. 2014), the average number of walk-ins per business type varies from 1.5 for convenience stores and restaurants to 7 in supermarkets and grocery stores. Approximatively 300,000 walk-in coolers exist in California across all establishment types.[10]

Evaporator Unit Market Potential

Leveraging California building stock data and evaporator measure density, it is estimated that the total stock of evaporator fans in the state amounts to about 1.1 million fans.[11]

Commercial evaporation units typically range in size from 1 to 6 fans. For the purposes of this technical potential assessment, VEIC assumed an average of 3 fans per unit. Therefore, the stock of evaporator units in California is approximately 750,000 evaporator units. Given a stock turnover of 15 years,[12] (estimated life of the measure) approximately 50,000 evaporator units are sold annually in the state.

According to distributors and manufacturers, HEEUs make up about 10 to 20 percent of current sales, which amounts to 5,000 to 10,000 HEEUs units sold annually. As noted previously, additional incentive programs would likely increase market adoption.

Condensing Unit Market Potential

The total sales of condensing units are much lower than evaporator sales for two main reasons: (1) multiple evaporator units are often tied to a single remote condensing unit and (2) not all refrigeration walk-in systems use an outdoor, remote condensing unit.

According to the 2014 California Commercial Baseline Study (Itron, Inc. 2014), the percent of remote condensing units varies by business type, as shown in Table 13 below. Thus, the total stock of condensing units in California is approximately one-third the size of the evaporator stock based on

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[10] The number of establishments for each business type was multiplied by the average number of walk-in coolers/freezers.

[11] Using information from ENERGY STAR Energy Use in Supermarkets (U.S. Environmental Protection Agency. January 2015. ENERGY STAR Portfolio Manager – Data Trends, “Energy Use in Supermarkets.”), stores average 0.2 walk-ins per 1000 square feet of building floor area. Additionally, stores average one evaporator unit per 100 square feet, with an overall average of 2.5 fans per 100 square feet.

[12] Measure life as sourced from Efficiency Vermont TRM, High Efficiency Evaporators measure, Active 1/1/2022. The source notation for this estimated measure life reads as follows: The 15-year measure life for evaporator fan motors is sourced from DEER 2014 effective useful life (EUL) estimates; California DEER 2014 Effective Useful Life Table Update, DEER2014-EUL-table-update_2014-02-05.xlsx. The 15-year measure life for evaporator fan motor controls is sourced from the EVT TRM measure characterization 'Evaporator Fan Motor Control'. The 15-year measure life for smart defrost controls is a conservative estimate based on an anecdotal conversation with Heatcraft, a manufacturer of refrigeration equipment. Heatcraft estimated the measure life based on the components expected life where the only moving part is a relay which has a cycle life that is well over 15 years based on the frequency of the relay operation. The 15-year measure life for the EEV is sourced from a case study, "Energy savings and economic benefits of using electronic expansion valves in supermarket display cabinets", R. Lazzarin, D. Nardotto, and M. Noro, July 2008. Due to all component attributes associated with the high-efficiency evaporator unit having a 15-year measure life, it was deemed appropriate to use this for each tier.

the saturation numbers and equates to just over 210,000 units. Based on a stock turnover rate of 13 years,[13] (estimated life of the measure), the annual number of condensing units sold is estimated at 16,000 units. While the size of remote condensing units can vary widely depending on the application, units in the size range of 0.5 to 6HP make up more than 70 percent of the market.[14]

According to distributors and manufacturers, many efficiency features that would qualify a unit as "high-efficiency" are not well established in the California market for distinct reasons (see Summary of Market Actor Interviews section). As a result, HECU models represent less than 5 percent of condensing units' sales. Assuming an average annual market penetration of 5 percent, approximately 800 HECUs are sold annually in California.

Table 13: Distribution of Business Type in California that Use Remote Condensing Units

Business Type	% Remote Condensing Units
Convenience stores	46
Gasoline stations with convenience stores	46
Supermarkets and other grocery stores (except convenience)	64
Warehouse clubs and supercenters	6
Restaurant and eating places	79

Source: California Commercial Saturation Survey Prepared for California Public Utilities Commission, Itron, Inc., August 2014

Measure and Savings Potential Estimates

Based on the market characterization detailed in this report, VEIC conducted a technical potential assessment to ascertain the impact of a midstream program in California. For program planning purposes, potential energy savings and incentive spending were quantified. These estimates were based on the early stages of a simplified adoption diffusion curve, representing a program in the

[13] Measure life as sourced from Efficiency Vermont TRM, High Efficiency Condensing Unit measure, Active 1/1/2022. The source notation for this estimated measure life reads as follows: "The expected measure life is 13 years, consistent with EVT's custom refrigeration analysis assumptions for a scroll compressor."

[14] According to interviews conducted with manufacturers. For the purposes of this potential assessment, an average system size of 3 HP is used.

early stages of launch rather than a comprehensive and mature market transformation program. Table 14 and Table **15** display results at the national and state levels.

VEIC leveraged a measure-based, bottom-up approach towards quantifying the potential market and impact for HECUs and HEEUs. The number of commercial refrigeration units sold annually in California was estimated using the 2014 California Commercial Baseline Study. State and national evaporator and condensing unit stock totals derived from the 2020 U.S. Census data supplemented these estimates. Potential savings and incentive values were calculated according to an applied market penetration rate gathered from interviews with key market actors.

Distributors and manufacturers estimate that 20 to 25 percent of the evaporators sold in California contain some efficiency components (they are most commonly missing EEVs and/or smart defrost). However, only 8 to 15 percent of evaporators sold contain all referenced components (see High-Efficiency Evaporator Units (HEEUs) subsection) to qualify as HEEUs as defined for this study.

For this analysis, a 10 percent adoption rate was assumed based on manufacturer and distributor adoption estimates. Additionally, a baseline density factor of 90 percent was applied to account for units with high-efficiency components already in the market. The incentives are assigned per fan, while savings are based on an estimated 1,923 kWh savings (Efficiency Vermont TRM, 2022) per unit (assumed to be 3 fans on average) and $250 in incentives per fan.[15] Therefore, the annual potential savings are estimated at 20,037 MWh with incentive potential reaching up to $2.6 million annually.

Table 14: HEEU Annual Measure Potential

	National Total		California Total	
Annual sale of equipment				
Total units (all efficiencies)	366,729	annually	38,549	annually
Total fans	1,100,187	annually	115,647	annually
High-efficiency measure market potential (annual) @ 10% market penetration				
Total HEEUs	33,042	units annually	3,473	units annually
Total fans	99,127	fans annually	10,420	fans annually
Program potential				
Incentives	$24,781,723	annually	$2,604,947	annually

[15] Incentive per fan is sourced from similar incentive structures from active midstream programs in Vermont and Detroit.

	National Total		California Total	
Energy Savings	190,621	MWh annually	20,037	MWh annually

Source: VEIC analysis

When asked about HECUs, the distributors and manufacturers surveyed estimated that 10 percent of condensing units sold in California have some efficient components (they are most commonly missing scroll or variable speed compressors). However, only 5 percent or less of annual sales of condensing units include units with all qualifying features to be considered HECUs as previously defined. Therefore, a 5 percent adoption rate was assumed for this analysis.

Additionally, a baseline density factor of 93 percent[16] was applied to account for units with high-efficiency components already in the market. Incentives are assigned per unit, while savings are based on an average of 3,506 kWh savings per medium temperature unit (70 percent of the market) and on an average of 2,753 kWh savings per low temperature unit (30 percent of the market)[17]. Therefore, the annual potential savings are estimated at 1,475 MWh with incentive potential reaching up to $1.13 million annually.

Table 15: Condensing Unit Market and HECU Annual Measure Potential

	National Total		California Total	
Annual sales of equipment				
Total units (all efficiencies)	133,808	annually	16,229	annually
High-efficiency measure market potential (annual) @ 5% market penetration				
Total HECUs	6,690	annually	755	annually
Program potential				
Incentives	$9,333,076	annually	$1,131,956	annually
Energy Savings	12,158	MWh	1,475	MWh

16 Value derived through analysis of saturation and commercial building stock data from the California Commercial Saturation Survey Prepared for CPUC, Itron, Inc., August 2014.

17 The average savings for medium-temperature and low-temperature units are based off the midpoint size offering in a 1/2-6HP program; the savings for a 3HP are then averaged for single phase and three-phase units, as taken from the Vermont TRM.

Source: VEIC analysis

Cost and Pricing Metrics

As mentioned previously, HEEUs cost 8 to 15 percent more than the standard efficiency equipment, and HECUs cost an additional 10 to 20 percent, typically in the $500 to $1,200 range (Distributor interview, 2023). This incremental cost estimate is supported by external TRMs which state incremental costs are (1) in the range of $600 to $1,300 (for 2-5HP range) for HECUs and (2) estimated at $1,060 for HEEU units supplied with a full suite of efficient componentry (fan motor controls, defrost control, EEV) (Efficiency Vermont, 2022).

The manufacturers interviewed were not able to provide more detailed or accurate equipment cost data at the time of this market study. Without more detailed cost data, an analysis of the equipment prices and cost variability across the market is not possible. Participant data from this Focused Pilot's on-site field monitoring and midstream incentive pilot programs, as well as research associated with measure package development preparation portion of this program, will provide information for incremental measure cost (IMC) analysis. The Focused Pilot will leverage all opportunities from the On-site Monitoring Pilot Program and Midstream Incentive Pilot to support measure package compilation. While there is not yet substantial data on this, the cost of installation and commissioning for newer HEEUs may be lower. According to one manufacturer interviewed, the increased simplicity of installation (two joints to braise in) and ease of programming using the digital interface have resulted in installation and commissioning time decreasing from over an hour with older imbedded controls to under 15 minutes.

Customer Purchasing Habits and Adoption Barriers

To identify barriers to adoption of HECU and HEEU, The Ortiz Group conducted a survey of hard-to-reach (HTR) and disadvantaged community (DAC) end users to characterize the purchasing decisions for this market sector. Small commercial customers with annual kWh energy spends under $100,000 were identified. The study also focused on two municipal government representatives with first-hand knowledge of equipment purchasing decisions for facilities owned and operated that serve low-income populations:

- The City of Berkeley owns and operates three senior centers, all of which maintain and operate full-service kitchens with walk-in refrigeration.
- The City of Avenal, characterized as a DAC, operates and maintains community centers and school facilities with walk-in refrigeration.

A refrigeration controls contractor and refrigeration contractor who work with HTR-DAC end users were also consulted. A summary of interviews to date is shown in Table 16 below.

Table 16: Summary of HTR and DAC Customer Interviews

HTR and DAC Customer Interviews	Interviewees	Total Interviews
HTR and DAC Municipal Gov't	City of Berkeley, Energy Efficiency Manager	2
	City of Avenal, City Manager	
Contractors Serving HTR or DAC	Cold Air Refrigeration	4
	NRM, Inc.	
	De Ochoa Heating and Air Conditioning	
	Alvarez Air One	
HTR and DAC Commercial	Retail – Local Butcher: 1	14
	Retail – Small Restaurant: 3	
	Retail – Market, Grocery: 2	
	Retail – Gas Station, Convenience Store: 2	
	Retail – Florist: 1	
	Retail – Supermarket: 2	
	Retail – Bakery & Deli: 1	
	Retail – Bar: 1	
	Community Center: 1	

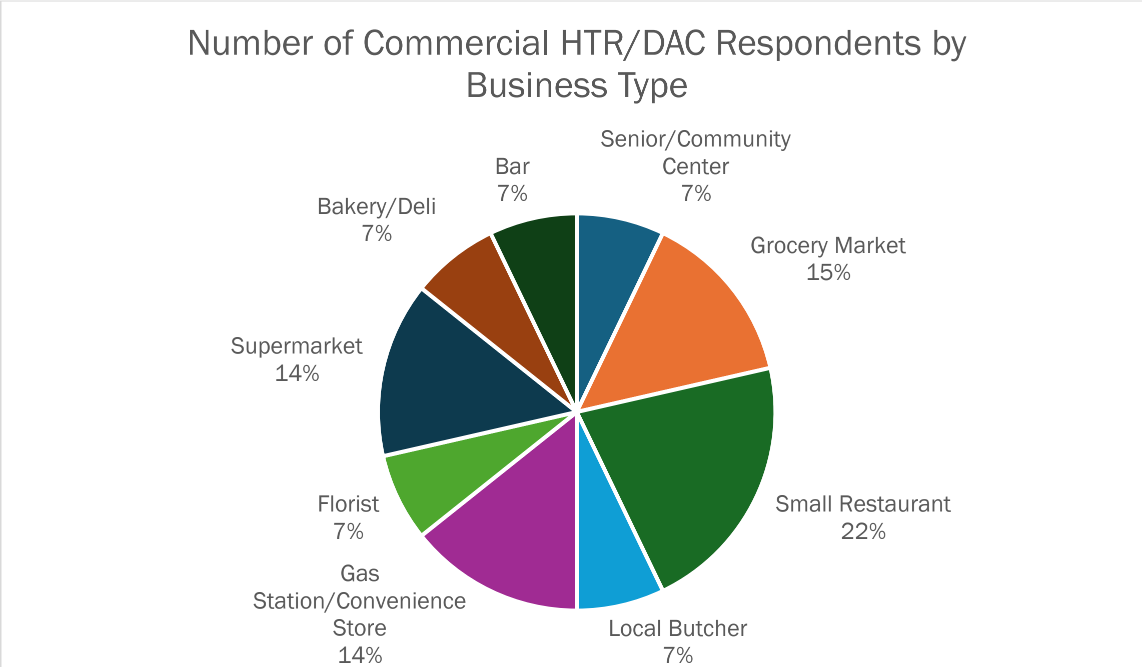

Figure 4: Breakdown of commercial business types represented

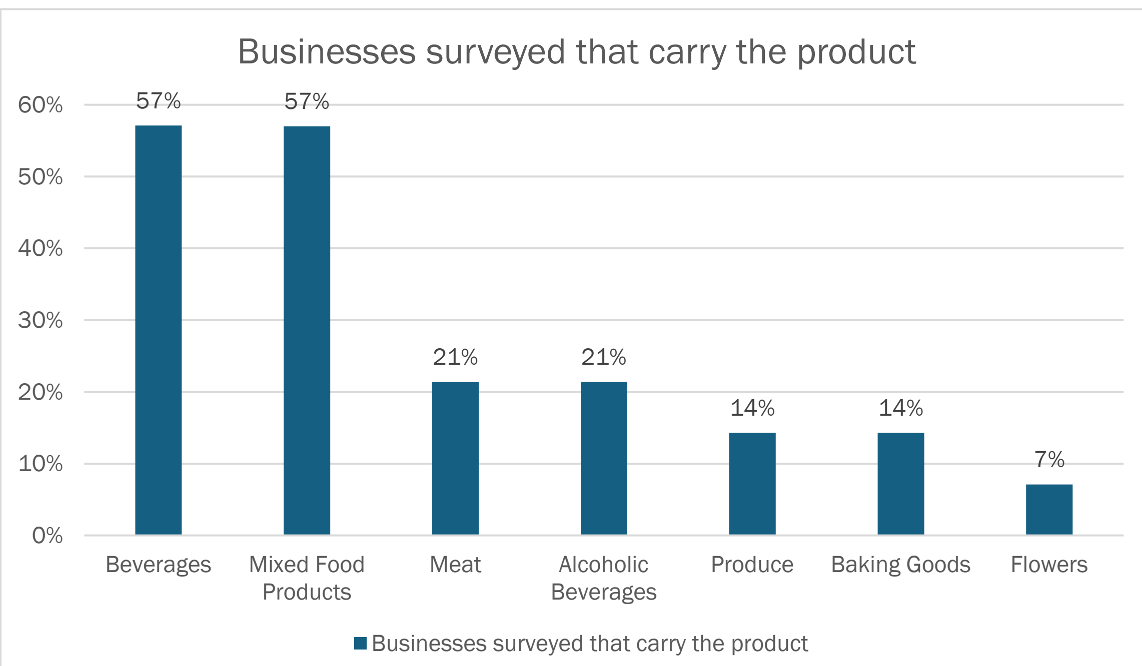

Figure 5: Percentage of businesses surveyed that carry the product

Note: Individual businesses may be represented in multiple product types

Table 17: Business Survey Responses

Survey Category	Statement	Percent of sites Surveyed that align with statement (%)	Notes
Business Profile	More than 10 years at current business location	50	
	Has more than one location	63.6	
	Has plans to move or expand within the next three years	4.5	
	Owns the space where the refrigeration equipment is located	68.2	
	Renters that are responsible for the maintenance of the refrigeration equipment associated with the refrigeration	60	
Refrigeration Details	Has 0 coolers	14.2	two sites
	Has 1 cooler	50	7 sites 1 door: 2 4 doors: 1 6 doors: 1 9 doors: 1 10 doors: 2
	Has 2 coolers	28.6	4 sites 2 doors: 1 4 doors: 2 8 doors: 3 12 doors: 2
	Has 3 coolers	7.1	1 site

Survey Category	Statement	Percent of sites Surveyed that align with statement (%)	Notes
			10 doors: 3
	Has 0 freezers	50	7 sites
	Has 1 freezer	42.9	6 sites 1 door: 3 2 doors: 2 10 doors: 1
	Has 2 freezers	7.1	1 site 1 door: 2
Concerns and Motivations	Think about the amount of electricity their refrigeration system uses	50 (7 of 14)	
	Are concerned with the costs associated with running their refrigeration system.	50 (7 of 14)	
	Have wondered if there are better, more efficient, and "cheaper-to-operate" options available	42.9 (6 of 14)	
	Reported considering replacing their condensing refrigeration system with a newer, more energy-efficient model as an accelerated replacement (before existing equipment failure)	14.3 (2 of 14)	Top reasons for considering HECU and HEEU options included: keeping their business operating (financial motivation), saving money by using more energy-efficient appliances, reducing greenhouse gas emissions and air pollution, and using less electricity to help reduce strain on California's electricity grid. Motivators included saving money in terms of operating cost, longer

Survey Category	Statement	Percent of sites Surveyed that align with statement (%)	Notes
			lasting equipment, newer equipment, and better efficiency. Reasons that customers didn't ultimately upgrade included cost of retrofit and lack of financing options, cost of retrofit and lack of cash flow, wouldn't know where to start understanding available options, not enough knowledge, and economic uncertainty.
	Concerned that existing refrigeration system might stop working and spoil some or all the refrigerated or frozen inventory.	50 (7 of 14)	Cost to replace damaged/spoiled inventory should the refrigeration system stopped functioning: $1,000 to $20,000
Level of Consumer Understanding of HECU and HEEU Technology:	Would be able to identify high-efficiency model amongst a variety of model choices.	0 (0 of 14)	
	Had some knowledge of the approximate costs to purchase and install HECU or HEEU.	42.9 (6 of 14)	
	Knew how much electricity their entire site used monthly	100 (14 of 14)	
	Knew about how much electricity existing refrigeration equipment consumes or costs relative to other appliances.	28.6 (4 of 14)	
Marketing	Customers reported having been contacted by businesses, contractors, distributors, or	21.4 (3 of 14)	

Survey Category	Statement	Percent of sites Surveyed that align with statement (%)	Notes
	manufacturers about purchasing a condensing unit or evaporator		
	Of those customers contacted, were offered high-efficiency condensing unit or evaporator options.	66.7 (2 of 3)	
	If so, did they try to persuade customer to purchase the more efficient model(s) instead of the standard model(s)?	66.7 (2 of 3)	

Table 18: Contractor (serving HTR or DAC) Survey Responses

Survey Category	Statement	Percent of sites Surveyed that align with statement (%)	Notes
Business Profile	Install solely for the owner of the building/property manager as opposed to the businesses renting the space	100	
	Annual installations of condenser and evaporator units in the 125 to 300 range.	100	Average of 215 units
	Serve small businesses	33.3	
	Serve convenience stores	16.7	
	Serve warehouses	16.7	
	Serve grocery stores	16.7	

Survey Category	Statement	Percent of sites Surveyed that align with statement (%)	Notes
	Serve strip malls	16.7	
Contractor Understanding of HECUs and HEEUs	Familiar with high-efficiency condenser and evaporator units	50	
	Would be interested in participating in a pilot program targeting the refrigeration market segment and receiving more information	50	
Marketing	Aware of HE condenser and evaporator units, recommend or promote HE models	100	
Barriers to Installing High-Efficiency Equipment	Cost to customers	100	

Summary of Purchasing Habits and Barriers for Hard-To-Reach Customers, Disadvantaged Communities' Customers, and National Chain Account Customers

Overall, customers are motivated to repair or replace equipment when it fails. Customers with refrigeration service contracts are especially motivated to repair or replace to avoid failure and consequent spoilage and loss of inventory.

On the whole though, HTR and DAC customers appear disinterested in early replacement of working refrigeration equipment or potentially do not see the value, even if incentivized. This could be due to the lack of clear energy-efficiency ratings and metrics for this type of equipment to clearly advertise the benefits to the customer.

Cost is the number one barrier preventing purchase of high-efficiency models, both from a customer and contractor perspectives. Overcoming this barrier requires a number of approaches. At a minimum, it requires clear and prevalent messaging about the value of the high-efficiency equipment.

Customers are conscious of energy costs, energy efficiency, and environmental issues, especially those impacting them directly, such as air pollution. Thus, marketing and education that includes the high-efficiency models' ties to these consequences would be beneficial. Currently, direct marketing to HTR and DAC customers about refrigeration is low. Based off this survey effort, customers who have learned about high-efficiency condensing unit and evaporator options would then consider the high-efficiency models.

Financial support — through both incentives and financing support — is another key lever in overcoming the cost barrier. Notably, this HTR/DAC survey effort indicated that incentives are not considered to be as important as spreading upfront costs over time with low-interest financing.

Peer Group Jurisdiction Program Benchmarking

Overview of Energy-Efficiency Programs

Interviews were conducted in February 2023 with managers of three different existing prescriptive rebate programs for high-efficiency condensing units and/or evaporator units. Interviews lasted about 60 minutes and included questions regarding key aspects of prescriptive programs such as incentive structure, participation levels, delivery model, key stakeholders, development history, challenges to implementation, and key metrics, among others. Programs were selected for an interview based on the following characteristics:

- Currently offering prescriptive incentives for HECU and/or HEEU units in their respective region
- Incentives offered through an energy utility or via a contracted energy-efficiency program administrator
- Program operating at least six months
- Availability of program staff to be interviewed

Table 19 below provides an overview of the programs integrated in this study review.

Table 19: Overview of Interviewed Prescriptive HECU AND HEEU Programs

Program Factor	Efficiency Vermont (EVT)	Mass Save	DTE Energy
Territory	Vermont	Massachusetts	Eastern Michigan
Technology	HECU, HEEU	HECU	HECU, HEEU
Program type	Midstream	Midstream	Midstream
Program age	HECU–5 Years HEEU–4 Years	4 Years	1 Year

Program Factor	Efficiency Vermont (EVT)	Mass Save	DTE Energy
Incentive and program budget	HECU per HP: $600/HP for <4 HP $400/HP for >= 4 HP Up to $2,400 per unit HEEU per fan: $250 per fan Up to $1,500/unit	Up to $1200 per unit $400,000 total budget for program	HECU per HP: Tier 1: $400/HP for 1-3 HP Tier 2: $200/HP for 3-6 HP HEEU per fan: Tier 1: $150 per fan Tier 2: $250 per fan $600K combined with the food service program.
Estimated per-unit deemed annual kWh savings	HECU = 3,112 kWh/unit/year HEEU = 3,979 kWh/unit/year	For HECU, estimated to be comparable in magnitude to EVT values due to similar VT and Mass TRM measure methodologies and structures	Quasi-custom approach[18]

Source: Program Staff Interviews, Feb 2023

Additionally, a review of 23 energy-efficiency programs (including those interviewed) across 15 states was conducted to provide a general overview of the prevalence of programs that incentivize the purchase of HECU and/or HEEU units or related individual componentry as part of a prescriptive or custom commercial refrigeration program. Appendix B provides a detailed program comparison. The main takeaways are as follows:

- Four of 23 (17 percent) of programs reviewed offer a prescriptive rebate program set up specifically for HECU and/or HEEU units.
- Seventeen of 23 (74 percent) offer a custom commercial project rebate or incentive option for commercial refrigeration projects[19]
- Two of 23 (8.7 percent) did not appear to offer either a prescriptive rebate or custom program for HECU or HEEU units or associated components.

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[18] DTE uses a custom savings methodology that incorporates binned HP ranges for HECU units similar to EVT/Mass Save's TRM methodologies.

[19] Most custom programs reviewed included an application process where project submissions are reviewed and determined eligible based on individual program requirements. This result counted programs that were deemed likely to approve projects involving HECU/HEEU installations in either retrofit or new construction applications based on available information.

Comparable California Market Offerings

For program year 2023, the California investor-owned utilities (IOUs) have several prescriptive offerings for the commercial refrigeration market adjacent to HECUs and HEEUs. After reviewing the California electronic Technical Reference Manual (eTRM)[20] the following prescriptive measures cover similar savings and installation scenarios:

- **Compressor Retrofit, Multiplex (SWCR012-02).** This measure pertains to the replacement of an air-cooled single-compressor refrigeration system with a multiplex system. The measure includes the specification of floating head pressure and condensing unit control methods.
- **ECM Retrofit for a Walk-In Cooler or Freezer (SWCR004-02).** This measure pertains to the replacement of shaded pole and permanent split capacitor motors with new electronically commutated permanent magnet motors (ECMs) in walk-in freezers and coolers.
- **Efficient Adiabatic Condenser (SWCR022-03).** Adiabatic condensing units function similarly to traditional air-cooled condensing units but integrate evaporative pre-cooling pads. They are available with variable speed fan capacity control and a fixed or two-speed saturated condensing temperature control.

Additionally, the California eTRM has prescriptive measure characterizations for floating head pressure controls and floating suction controls, but they are specifically for multiplex systems. Hence, these measures do not compete for the same baseline replacement equipment, as HECUs are not a typical option for multi-rack refrigeration systems.

The prescriptive solution offerings are heavily focused on larger rack compressor systems. This creates an opportunity for a potential HECU measure to fill a glaring market gap, i.e., the ability to assist and impact smaller single-compressor commercial refrigeration systems used at businesses such as neighborhood markets, convenience stores, restaurants, and HTR or DAC foodservice locations. All interviewed energy-efficiency program managers specifically targeted this gap when designing their offerings.

Key Characteristics of Program Design

Based on the three program manager interviews, the following common characteristics appear critical to the successful implementation of a prescriptive HECU-HEEU program.

Emphasis on developing and maintaining robust relationships with key regional supply chain stakeholders, i.e., manufacturers, distributors, and contractors. Open lines of communication, clear program guidelines, and a streamlined process for issuing incentive payments are important to encourage and build participation in a program. Strong relationships with distributors and contractors also help to encourage faster adoption of recent technology. They also provide an opportunity to introduce the program to a large audience in an efficient manner, as regional distributors often overlap with multiple contractor networks. Established lines of communication with

[20] The CA eTRM was developed by the California Technical Forum and is an online application that serves as the repository for all statewide deemed measures. Last updated on December 14, 2022.

contractor partners also provide distributors and manufacturers with feedback on product performance in the field. This in turn helps distributors identify which products to stock and helps manufacturers identify which models to supply or improve. A successful prescriptive incentive program seamlessly incorporates itself into the supply chain ecosystem in a manner that is seen as a resource by each individual stakeholder to help achieve business goals such as increased sales, customer satisfaction, and market share, all while driving market transformation towards a more energy-efficient technology.

"Become friends with the dealers that you're going to be launching it with. You know, if that takes having a lunch with them…be there as it launches and explain to them what the program is, how it works, and how simple it is for the different dealers to use a program." – Program Manager Interviewee

Incentive delivery structure of the program. All three programs employ a midstream delivery model where incentive payments are made to distributors and contractors and then passed along to the end-user customer. A midstream program structure pairs particularly well with the HECU and HEEU technologies due to specifics of the commercial refrigeration equipment industry. Unlike other equipment used in commercial food service (such as kitchen appliances), refrigeration equipment requires certified contractors to install and service. By offering incentives directly to contractors and distributors, a midstream program is positioned to leverage existing contractor and distributor networks. As a result, the program reaches a larger population than if end-user customers were targeted in a downstream program structure. It also allows for an efficient incentive delivery structure where a single contractor or distributor processes and passes along incentives for a large number of customers.

"Once you make it real simple and show them it's hardly anything they have to do and they don't have to worry about not losing out on money, they can do credit memos. It goes a lot easier for everybody." – Program Manager Interviewee

Leveraging of an established prescriptive savings model to support savings evaluation and verification. Use of a vetted methodology for HECUs and HEEUs, such as is provided in a TRM characterization, allows for reliable, repeatable savings calculations that can be easily evaluated. In addition, leveraging a fully prescriptive or quasi-custom savings calculation methodology reduces a program's expenditure on engineering resources and in turn increases cost-effectiveness.

"The success of the program is measured in energy savings." – Program Manager Interviewee

Common Barriers and Challenges

Program manager interviews also surfaced common barriers and challenges experienced by each program to some degree or at various points in the program life cycle.

Contractor and distributor reluctance. Some of the challenges experienced at the introduction of a program involved overcoming initial reluctance of contractors and distributors to sell the HECU and HEEU technology to customers. Often this reluctance was driven by a lack of contractor experience with the new equipment. A common piece of feedback provided to program managers during the initial program launch period was that reliability is customers' number one concern, especially for commercial refrigeration. Contractors therefore default to what they believe to be the most reliable options, which tends to be the existing, less energy-efficient technologies. Engaging manufacturers in conversation with contractors and distributors is an important lever to overcoming this barrier. To drive initial uptake, program managers cited examples of manufacturers providing contractor teams with HECU-HEEU-specific training to help increase familiarity and confidence in the equipment.

"We're about just helping the contractors to be brave and take the lead. It wasn't as much like we need to, you know, substantially raise their technical savviness …it really wasn't as much of that as it was just demystifying (things) like, you know, this new little digital control panel…"

Difficulty with growing program participation. In Efficiency Vermon's (EVT) case, the HECU program was initially targeted at agricultural applications due to strong distributor and contractor relationships already in place for that market segment. Expanding to a larger customer base required EVT staff identify new stakeholder partners serving other commercial refrigeration applications and to develop new relationships with said partners. Program staff agreed that although building stakeholder relationships takes time, those relationships play an essential role in the success of the program.

"It's (a) ground up program (and) you have to teach the market that it's there, going through the contractors, you have to go, you know, basically store by store or location by location and talk with the salespeople and the different branch managers and explain the program, explain how it works."

Difficulty with growing program participation was also attributed to issues with equipment availability and stocking levels. As explained by interviewed market actors, in commercial refrigeration applications if a piece of equipment goes down, customers require the equipment to be repaired or replaced as soon as possible. As discussed previously, this results in contractor purchasing habits leaning towards the equipment distributors keep in stock, which is subject to the availability of equipment being supplied from manufacturers. Program staff involved with DTE Energy's HECU-HEEU program reported that a lack of availability of HECUs in the Detroit area in the 2022-2023 program year had a direct effect on uptake of the technology in the program.

"[They're] off to a great start (with) evaporators, they don't have condensing units in the area. That's been very slow… I think we had like 50 evaporators and maybe 4 condensers… because they just aren't available."

Overall, common key barriers reported by interviewed program managers were all related in some degree to, and resolved through, building relationships with manufacturer, distributor, and contractor partners. It was recommended that a prospective HECU-HEEU program in California should spend time learning the market landscape, i.e., identifying and making connections with national manufacturers who offer HECU-HEEU technology in the state, regional distributors and contractors who service commercial food service customers, and the end-user customers themselves. In existing HECU-HEEU programs, these relationships have proven invaluable in helping encourage program participation, effectively delivering incentives, and transforming markets.

Summary of Preliminary Findings Report Key Findings

This section provides a summary of key findings and insights, as well as the project team's conclusions regarding the state of the market, potential growth opportunities, and challenges for businesses operating in this sector. It is intended to help market participants make informed decisions and develop effective intervention strategies for navigating this complex and dynamic market.

Key Finding #1: Customer Purchasing Habits and Stocking Practices within the Supply Chain are Key Determinant of Technology Adoption

According to the manufacturers interviewed, most commercial refrigeration customers rely on contractor knowledge to recommend equipment based on operational needs and existing systems. Contractors then work with distributors to fulfill those needs.

Distributors in California, however, mentioned that HECUs are difficult to stock for a few reasons. First, there is not a broadly applicable HECU model. This is due to the many component variations to consider based on the customer's unique context, such as voltage, refrigerant type, power rating, temperature application, and cabinet size. With all these featured options, it is difficult for manufacturers to stock all the models required to meet the market needs. The high-efficiency components provide additional variables and sizing requirements, making it difficult for distributors to know which models and features to keep in stock. Also, in today's market, demand is low for specialized efficiency features like floating head pressure controls, demand defrost, and scroll compressors due to high incremental cost above basic options. Since certain energy-efficiency components are already required by California codes, such as ECM motors, the additional features that would qualify the equipment as a higher-efficiency option are seen as extra, cost-adding choices.

As a result, distributors typically keep only standard condensing units in stock. Distributor stock is often a key factor in whether a customer will install an HECU or HEEU. When a customer is looking to replace an existing piece of equipment due to failure or poor operation, a quick turn-around for installation of new equipment is essential. If the equipment is not in stock with the distributor or supplier, then the contractor has no choice but to choose a standard efficiency unit.

While HECU systems are largely special order, HEEUs are more readily available because distribution centers tend to stock systems with smart defrost controls, fan motor controls, and EEVs. Upfront costs and immediate replacement of failing equipment with a reliable option were critical in the decision-making process for customers.

Another consideration for customers' purchase of both HECUs and HEEUs is the control system. Since controls with programmable interfaces are crucial for high-efficiency features to function, they must be included in qualifying units. However, at present, each manufacturer has its own specialized controls that are incompatible with other manufacturers' products. In addition, most of these controls need to be pre-installed at the factory as part of the HECU-HEEU pair. As a result, customers with incompatible, already-installed control systems or equipment are unlikely to adopt an HECU or HEEU over a standard unit type.

Key Finding #2: Market Factors and Installation Requirements Impact the Condensing Unit and Evaporator Unit Market Differently

The market share of evaporators with non-ECM motors has dwindled. In addition, due to the high penetration of units with ECM fan motors, as well as increasing stringency on minimum qualifying criteria in code, programs like Efficiency Vermont have dropped savings and incentives for this feature in their solution offering.

California has standards that are driving towards higher-efficiency equipment, with minimum specific efficiency requirements for select applications of commercial refrigeration. Traditionally these standards have not applied to HECUs because of specificity in code not necessarily applying to remote condensing units, which is the largest market for replacement and adoption of this measure.

According to manufacturers interviewed, high-efficiency evaporators make up 10 to 20 percent of current sales in the market. Application and installation for this technology is markedly easier compared to HECUs. This is likely due to less complexity in the design. Given the more nascent nature of the energy-efficient market, relevant sources of burden include (1) the difficulty and unfamiliarity of installation, especially in consideration to the control component and (2) requiring a higher level of technological integration and commissioning from contractors.

Key Finding #3: Supporting HECU and HEEU Systems Rather Than Individual Energy-Efficiency Components is Key to Accelerating Adoption

Most manufacturers of remote condensing and evaporator units have high-efficiency options and components offered in their product lines. Many of the California IOUs have programs that incentivize individual components typically included as standard or optional efficiency features for retrofit and equipment replacement. Currently, no IOU program incentivizes the full package of efficiency measures that may comprise a high-efficiency unit when installed at end-of-life or in new constructions. In contrast, this study found that variable speed compressors, fully modulating condensing unit fan controls, ultra-low head pressure setpoints, and integrated controls offer the highest efficiency potential for condensing units. Similarly, electronic expansion valves, optimized defrost controls, fully modulating evaporator fan controls, and integrated controls to reduce excessive superheat offer the highest efficiency potential for evaporator units.

Key Finding #4: Market Actor Relationship Building is Critical to a Successful Energy-Efficiency Program

Common key barriers reported by interviewed program managers all pertained to stakeholder engagement. Strong relationships with manufacturers, distributors, and contractors are critical to program participation and effective incentive delivery. Thus, prospective HECU and HEEU programs in California should spend time learning the market landscape and engaging with these market actors.

Summary of Gaps and Barriers for Measure Adoption

This study identified three critical barriers for widespread measure adoption throughout the state of California and makes recommendations for tackling them.

First Costs

Incremental cost for HEEUs and HECUs (8 to 15 percent and 10 to 20 percent respectively) disproportionately affects smaller businesses. Unexpected replacement costs associated with replace-on-burnout scenarios can be an insurmountable burden. Initial and up-front equipment costs are the main driver behind a customer decision despite long-term energy and cost savings from implementing high-efficiency technologies. **As part of an energy-efficiency program, utilities can tackle this barrier via monetary incentives.**

Lack of Stock and Supply Chain Lead Times

Distributors often stock qualifying HEEU options but most of their stock is comprised of standard efficiency and qualifying HECUs are not typically kept in stock. Unavailability of HECUs and HEEUs can add weeks or months to a project timeline, thus increasing the likelihood of defaulting to a standard option. The negative impact of this stocking practice increases under an emergency replacement scenario. **As part of their energy-efficiency offerings, utilities can promote the stocking of high-efficiency options through meaningful engagement with supply chain actors.** As an example, at the launch of DTE Energy's HECU-HEEU energy-efficiency program in Michigan, only four HECU model options were available in the market. An increase in the number of available options is correlated with the intervention of their program in the Detroit market.

Contractor Reluctance and Education

Distributors fulfill contractors' request for specific equipment. In addition, contractors' recommendations — formulated mostly based on availability, familiarity, and initial costs of products — dictate customer purchasing habits. Hence, contractors' resistance to change is a major barrier to adoption, especially for key component such as EEVs and digital controls.[21] Drivers of contractor reluctance toward adoption include perceived risk to their business, concerns over customer satisfaction, lack of experience, and time investment associated with learning a new system. As HECUs leverage more dynamic control strategies than the baseline condensing unit options, they require greater familiarity with computer-based systems, an educational component to these measure that represent a barrier to wider adoption. **Workforce training and demonstration projects are critical to increase the likelihood of contractors recommending, offering, and correctly installing HECUs and HEEUs at client sites.**

[21] See Summary of Market Actor Interviews.

Section 2. On-site Monitoring Pilot Program

Objectives

The first objective of the on-site monitoring component of the Focused Pilot was to obtain data on field operation to be used to understand and quantify energy and GHG emission savings resulting from equipment installations. The second intended outcome was to understand customer and contractor decision making with respect to their refrigeration equipment, with particular focus on how they weigh factors such as cost, energy savings, greenhouse gas emissions, and reliability.

Methodology and Approach

Projects were selected for monitoring representative of the key customer types and climate zones for this type of equipment in California. On-site monitoring equipment was installed by the Focused Pilot team and monitoring included both pre- and post-installation collection periods to collect both baseline and new equipment data points. Sites were recruited by the Focused Pilot team and a customer agreement was developed for each selected project. Customers were responsible for installing high-efficiency condensing units and evaporators at the selected sites according to all applicable licensing and permitting requirements. Data from facility energy management systems (EMS) would have been collected and used, but it was not available at any of the sites. Primary data collected included ambient temperature and relative humidity, evaporator inlet temperature and relative humidity, door opening status, package power (voltage, amperage, and power factor) for both condensing units and evaporators. In exchange for permission to conduct on-site monitoring, EMS data sharing, interviews with key contacts, and access to meter data (if possible), the full cost of equipment and installation was covered for the site, up to $15,000 per project. The monitoring followed the California Monitoring and Evaluation Protocol set by the CPUC. The Measurement and Verification (M&V) plan is attached in Appendix F. A survey was also conducted of customer and installing contractor or service provider to document purchasing habits, project barriers, satisfaction with equipment and energy and GHG saving features, and temperature control of the new efficient equipment (Appendix I).

Site Eligibility Requirements

Geographic site eligibility of site for participation in the On-site Monitoring Pilot Program has been created and is available for lookup online at https://caenergywise.com/instant-rebates/#customer-eligibility.

The following foodservice-related business types were determined eligible for on-site monitoring participation:

Table 20: Foodservice Business Types

Sector Category	Site Types Considered
Education	Community college
	Primary school
	Secondary school
	University
Food Supply	Food processing facility
	Warehouse
Health/Medical	Hospital
	Nursing home
Lodging	Hotel
	Motel
	University dormitory
Markets	Grocery store
	Supermarket
Municipal	Assembly
	City parks/recreation
	Government facility
Office	Large
	Small
Restaurants	Fast-food
	Sit-down

Existing equipment also factored into site eligibility for participation in the site monitoring pilot project. Eligible WICFs, condensing units, evaporators, and sites were required to:

- Have a functional walk-in cooler or freezer.
- Have an existing condensing unit or evaporator system with a compressor rated at 10 horsepower or less.
- Existing "rack refrigeration" systems were not eligible.
- Permit site-monitoring staff on-site for installation and removal of data logging equipment.
- Install qualifying high-efficiency equipment after pre-monitoring data collection was complete.
- Install new equipment by program end date.
- Avoid changes to use type, frequency, or the installation of gaskets, new flowing, new shelving, new lighting, or any other energy-efficiency measure that would skew data during the pre- and post-monitoring phases.

Site Monitoring Locations

The pilot team partnered with 10 sites for WICF refrigeration equipment monitoring. Sites are shown in Table 21, below. For six sites, the final customer equipment and labor cost associated with pilot participation were totaled to $550 or less. The pilot provided $149,727 in customer stipends to offset equipment removal and installation costs.

Table 21: Site-monitoring locations

Site	Business Type	Location	Replacement Equipment	Total Project Cost	Customer Stipend	Final Customer Cost
Site 01	Restaurant and beer garden	Oakland, CA	HECU & HEEU	$15,025	$15,000	$25
Site 02	Restaurant	Stanton, CA	HECU & HEEU	$15,000	$15,000	$0
Site 03	Senior living facility	Rancho Santa Margarita, CA	HECU & HEEU	$19,792	$15,000	$4,792
Site 04	Restaurant	Huntington Beach, CA	HECU & HEEU	$15,000	$15,000	$0
Site 05	Warehouse	Brisbane, CA	Low-GWP Package System	$20,805	$15,000	$5,805

Site	Business Type	Location	Replacement Equipment	Total Project Cost	Customer Stipend	Final Customer Cost
Site 06	Corner store	San Francisco, CA	HECU & HEEU	$27,000*	$15,000	$12,000*
Site 07	Restaurant	Clovis, CA	HECU & HEEU	$14,727	$14,727	$0
Site 08	Restaurant	Selma, CA	HECU & HEEU	$15,259	$15,000	$259
Site 09	Coffee shop	Selma, CA	HECU & HEEU	$16,640	$15,000	$1,640
Site 10	Restaurant	Fresno, CA	HECU & HEEU	$15,550	$15,000	$550

*Total project cost includes auxiliary work not directly related to site monitoring equipment

Data Analysis Methodology

Data Quality Control

The baseline- and replacement-system recorded datasets for each of the 10 sites were provided to the data quality control (QC) team for review. Each dataset was inspected for missing entries and anomalous readings, e.g., from sensor or logger malfunction. Any identified issues were brought to the attention of the field monitoring teams for verification and remedy or correction where possible.

Data Analysis

The QC team was also tasked with the complete data analysis to generate daily energy summations and temperature averages, and to normalize energy use for ambient temperature conditions using regression models comparing condensing unit energy vs. temperature. Additionally, the datasets were normalized for California's 16 climate zones. The regression modeling and normalization methodology is discussed in Section 5. Equipment Energy Regression Modeling Summary data showing regressions modeling and normalization is found in Appendix J.

Daily Averages: The primary approach for the data analysis involved calculating daily averages for indoor air temperature, outdoor air temperature, and condensing unit energy consumption. This daily aggregation was chosen to smooth out short-term fluctuations and focus on broader trends and patterns, which were used later to normalize the datasets. In cases where daily averages did not produce a strong regression — likely due to variability in operational conditions, or insufficient number of data points to generate a strong regression — hourly averages were used.

Site Monitoring Energy Savings Results

For the results data tables below, walk-in coolers were categorized as medium-temperature systems, and the walk-in freezers were categorized as low-temperature systems.

Total System Monitoring Results: Condensing Unit and Evaporator

The normalized total-system yearly energy use for each of the 10 monitored WICFs is shown in the tables below. Table 22 shows annual energy use for baseline systems, retrofit systems, and annual energy savings from retrofit systems. Table 23 shows the site-aggregate average baseline, retrofit, and savings, based on the system temperature category.

Table 22: Total System Yearly Energy: Baseline, Retrofit, and Savings

Site	Location	Climate Zone	System Temp	Baseline Yearly Energy [kWh]	Retrofit Yearly Energy [kWh]	Difference in Yearly Energy [kWh]
Site 01	Oakland, CA	3	Medium	5,987	4,828	(1,159)
Site 02	Stanton, CA	8	Medium	8,249	3,486	(4,764)
Site 03	Rancho Santa Margarita, CA	8	Low	15,250	8,578	(6,673)
Site 04	Huntington Beach, CA	6	Medium	8,396	5,124	(3,272)
Site 05	Brisbane, CA	3	Medium	7,688	2,541	(5,147)
Site 06	San Francisco, CA	3	Medium	14,182	5,935	(8,247)
Site 07	Clovis, CA	13	Medium	11,130	2,389	(8,741)
Site 08	Selma, CA	13	Medium	10,955	8,626	(2,328)
Site 09	Selma, CA	13	Low	14,891	8,638	(6,252)
Site 10	Fresno, CA	13	Medium	8,863	4,964	(3,899)
Site Totals	All sites		All	105,591	55,110	(50,482)

Table 23: Total System Yearly Energy: Average Baseline, Retrofit, and Savings

	System Temp	Baseline Yearly Energy [kWh]	Retrofit Yearly Energy [kWh]	Difference in Yearly Energy [kWh]
Site average–all	All	10,559	5,511	(5,048)
Site average–low temp	Low	15,070	8,608	(6,463)
Site average–medium temp	Medium	9,431	4,737	(4,695)

Condensing Unit Monitoring Results

The normalized yearly condensing unit energy use for each of the 10 monitored WICFs is shown in Table 24 below. Table 25 shows the site-aggregate averages, based on the system temperature category.

Table 24: Condensing Unit Yearly Energy Comparison: Baseline, Retrofit, and Savings

Site	Location	System Temp	Baseline Normalized Condensing Unit Yearly Energy [kWh]	Retrofit Normalized Condensing Unit Yearly Energy [kWh]	Difference in Normalized Condensing Unit Yearly Energy [kWh]
Site 01	Oakland, CA	Medium	4,848	3,691	(1,156)
Site 02	Stanton, CA	Medium	6,052	2,816	(3,236)
Site 03	Rancho Santa Margarita, CA	Low	12,505	5,433	(7,072)
Site 04	Huntington Beach, CA	Medium	6,865	4,133	(2,733)
Site 05	Brisbane, CA	Medium	5,147	2,072	(3,075)
Site 06	San Francisco, CA	Medium	11,953	4,721	(7,232)

Site	Location	System Temp	Baseline Normalized Condensing Unit Yearly Energy [kWh]	Retrofit Normalized Condensing Unit Yearly Energy [kWh]	Difference in Normalized Condensing Unit Yearly Energy [kWh]
Site 07	Clovis, CA	Medium	9,553	2,107	(7,447)
Site 08	Selma, CA	Medium	7,420	7,128	(292)
Site 09	Selma, CA	Low	13,413	7,295	(6,118)
Site 10	Fresno, CA	Medium	7,505	4,408	(3,097)
Site Totals	All sites	All	85,261	43,804	(41,457)

Table 25: Condensing Unit Yearly Energy Comparison: Average Baseline, Retrofit, and Savings

Yearly Energy Comparison Type	System Temp	Baseline Normalized Condensing Unit Yearly Energy [kWh]	Retrofit Normalized Condensing Unit Yearly Energy [kWh]	Difference in Normalized Condensing Unit Yearly Energy [kWh]
Site average–all	All	8,526	4,380	(4,146)
Site average–low temp	Low	12,959	6,364	(6,595)
Site average–medium temp	Medium	7,418	3,884	(3,533)

Evaporator Monitoring Results

The normalized yearly evaporator energy use for each of the 10 monitored WICFs is shown in Table 26 below. Table 27 shows the site-aggregate averages, based on the system temperature category.

Review of evaporator fan speed in Appendix J – Site Monitoring Summary Data show multiple sites may have evaporators with only one fan speed enabled after retrofit install and during site monitoring. These observations occur at multiple sites, with equipment installed by three separate contractors, and using equipment featuring factory-enabled varying fan speeds. Follow-up conversations with manufacturer trouble shooting department representatives show that some manufacturer representatives may suggest disabling low-fan-speeds as part of the troubleshooting process. Other representatives or field contractors may disable low fan speeds as a perceived best practice. This was observed despite site monitoring retrofit installation contractors being educated on the purpose of the HEEU features and knowing energy use was being monitored for future measure package or program reference. This points to the need for contractor training on proper installation of evaporator fan controls and the benefits of proper installation. Differences in annual energy savings (kWh) of evaporators may not reflect the full potential savings of correctly installed equipment.

Table 26: Evaporator Yearly Energy Comparison: Baseline, Retrofit, and Savings

Site	Location	System Temp	Baseline Evap Yearly Energy [kWh]	Retrofit Evap. Yearly Energy [kWh]	Diff Evap. Yearly Energy [kWh]
Site 01	Oakland, CA	Medium	1,139	1,137	(3)
Site 02	Stanton, CA	Medium	2,197	669	(1,528)
Site 03	Rancho Santa Margarita, CA	Low	2,745	3,144	399
Site 04	Huntington Beach, CA	Medium	1,531	992	(539)
Site 05	Brisbane, CA	Medium	2,541	469	(2,073)
Site 06	San Francisco, CA	Medium	2,230	1,215	(1,015)
Site 07	Clovis, CA	Medium	1,577	282	(1,295)
Site 08	Selma, CA	Medium	3,535	1,499	(2,036)
Site 09	Selma, CA	Low	1,478	1,343	(135)
Site 10	Fresno, CA	Medium	1,358	557	(801)
Site Totals	All Sites	All	20,330	11,306	(9,025)

Table 27: Evaporator Yearly Energy Comparison: Average Baseline, Retrofit, and Savings

Yearly Energy Comparison Type	System Temp	Baseline Evap Yearly Energy [kWh]	Retrofit Evap. Yearly Energy [kWh]	Diff Evap. Yearly Energy [kWh]
Site average– all	All	2,033	1,131	(902)
Site average– low temp	Low	2,111	2,244	132
Site average– medium temp	Medium	2,013	852	(1,161)

Site Monitoring Survey Results

From the survey, the project team gathered feedback from customers at eight sites and from contractors that served eight sites. These are the highlights from the surveys:

- When customers are choosing refrigeration equipment, ongoing maintenance costs, reliability, and cooling performance are the most important factors; all customers rated them “very important.”
- When customers are choosing refrigeration equipment, previous experience with the equipment, cutting-edge technology, ongoing energy costs, low-GWP, and quiet operation were the least important factors, receiving at least one-third of responses at the “important” level or below, with at least one response “slightly Important” or lower.
- According to customers, electrical bills remained either about the same or decreased for most of the sites; one site reported that electric bills have decreased by about $100 per month.
- When considering customer satisfaction with the new equipment across various factors, reliability, ongoing energy, temperature controls, and cooling performance received the highest marks, with at least seven of eight responses being “very satisfied” for each factor.
- Lead times for retrofit equipment were up to around eight weeks for some of the sites.
- For contractors trying to determine which model to select, customer satisfaction is the most important factor they consider; three of three contractors listed this as “very Important” for all eight sites they served in this pilot.

Section 3. Midstream Incentives Pilot Program

Objectives

The objective of the Midstream Incentive Pilot Program is to test the effectiveness of midstream incentives in promoting the stocking and sales of high-efficiency condensing units and evaporators.

Methodology and Approach

As identified in the Market Characterization Study, barriers to adopting high-efficiency refrigeration equipment for walk-in coolers and freezers include increased costs at the customer level, in-stock inventory at the distributor level, and contractor education. To address these barriers, the preliminary pilot design included the following:

- Incentives to equipment distributors in two treatment groups: (1) To test a point-of-sale model, where incentives must be passed through to customers and distributors are provided a per-unit incentive (spiff) for providing the customer incentive as a reduction on a customer or contractor's sales invoice. (2) To test a traditional midstream incentive paid to distributors and not requiring pass-through to customer.
- Incentive amounts were determined based on information gathered in the market characterization study and estimated incremental measure cost (IMC).
- Educational materials for distributors for both treatment groups.
- Distributor training on high-efficiency equipment upselling techniques and custom support to influence stocking practices.
- Training webinars for contractors on high-efficiency equipment benefits, availability, and costs to influence customers purchasing practices.
- A survey of participating distributors to obtain feedback on pilot design and effectiveness.
- Targeting two distributors for each treatment group.

Incentive Logistics

To efficiently market, review, approve, and pay incentive claims, the pilot team:

- Built an online application portal (Iris) for distributors to request incentive reimbursements.
- Developed QPL (See Section 4. Qualified Products List below for more information).
- Established incentive pricing structures (more information is in Section 4. Qualified Products List).
- Determined customer eligibility through an online zip code lookup tool available at https://caenergywise.com/instant-rebates/#customer-eligibility.

Distributor Participation

Four dealers fully enrolled to participate in the midstream incentive pilot. Of the four, only three submitted claims during the eligible sales window of November 1, 2023, through May 31, 2024. The participating distributors were United Refrigeration, Refrigeration Supplies Distributor, and American

Refrigeration Supply; Allied Refrigeration Inc. did not submit any claims for incentive reimbursement. As shown in Table 28, participation varied by distributor with American Refrigeration Supply submitting the most claims. As shown in Figure 6, a number of models were submitted and incentivized by the midstream pilot, but Trenton and Russell were the only two manufacturers represented, and all models were part of three model series or lines. It is notable that no condensing units were incentivized; this was an unexpected outcome that the project team explored further with distributors in the post-program interviews, as described in Distributor Interview Results below.

Table 28: Midstream Point-of-Sale Pilot Distributor Participation

Distributor	Participation Type	Number of HEEU Models Incentivized	HEEU Model Series Incentivized	Number of HECU Models Incentivized	Total Incentive Value	Total Spiff Value
United Refrigeration	Pass-through	5	TPLP	0	$1,650	$250
Refrigeration Supplies Distributor	Pass-through	5	RL6A, RL6E	0	$7,500	$250
American Refrigeration Supply	Non-pass-through	23	RL6A, RL6E	0	$13,250	$1,150
Allied Refrigeration Inc.	Non-pass-through	0	N/A	0	$0	$0

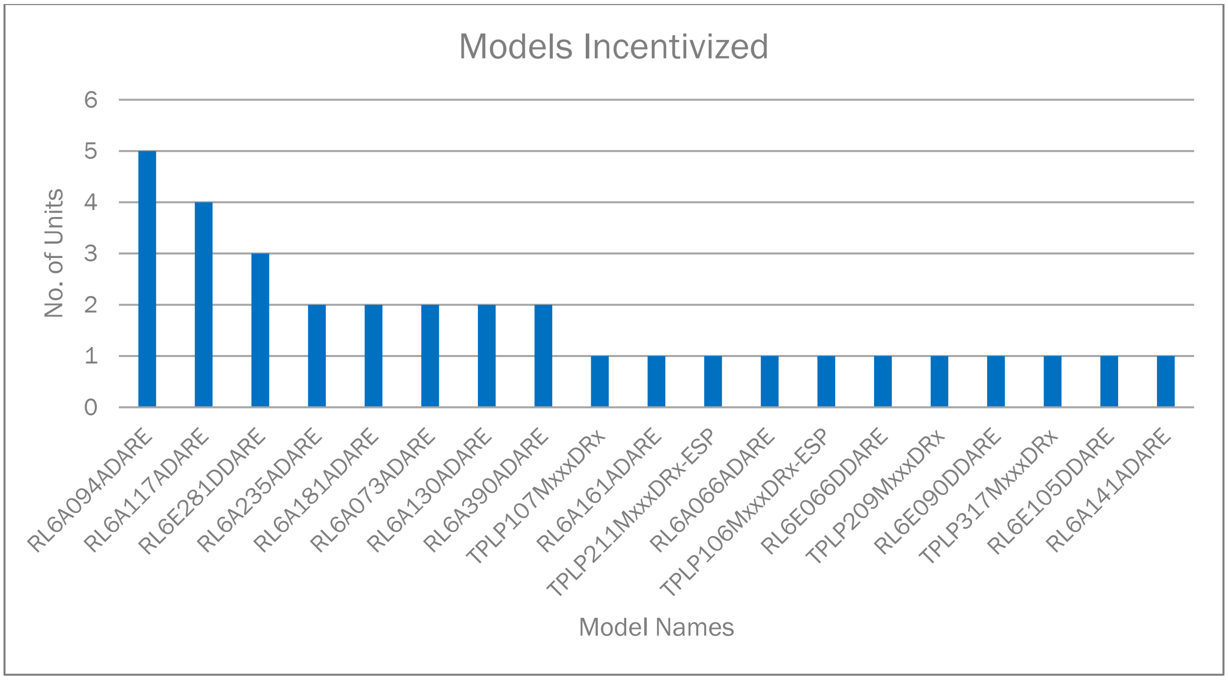

Figure 6: Midstream pilot models incentivized

Distributor Interview Results

Of the three participating distributors, two engaged in post-pilot interviews. These interviews were opportunities to better understand the distributors' experiences with the pilot. The feedback from these distributors was overall positive. Both distributors stated this pilot increased the number of high-efficiency units they were able to sell and said they would want to participate if the pilot became more permanent.

Regarding stocking behavior, the feedback implies that the incentive had a neutral-to-positive impact. One distributor stated they had already been stocking the equipment prior to the pilot; the other noted they stocked very few prior to the pilot and stocked significantly more during it. One distributor reported that sales of high-efficiency equipment increased by more than 10 times during the pilot period alone, compared to the entire previous year.

Regarding contractors' roles in adoption of the higher-efficiency models, one distributor noted that in most high-efficiency sales, it was the distributor, not the contractor or customer, who had suggested contractors consider purchasing the high-efficiency models. This potentially reflects a lack of awareness and/or a hesitancy to adopt new technology. According to the interviewed distributors, contractor pushback did not always happen, but when it did, it was usually due to concerns about cost and ease of installation. With the pilot, contractors were successfully able to offset the incremental cost to the customers.

The interviews also endeavored to understand the notable lack of condensing unit claims. According to one distributor, the results were unsurprising as manufacturers did not have qualifying HECU available for stocking. The pilot teams' communications with manufacturers, as well as HECU models sourced in the site monitoring pilot, confirmed qualifying HECUs are available but are not highly produced or stocked. Additional distributor feedback conveyed that the HECUs typically are sold as custom orders which further limits stocking for as-fails scenarios. Given long lead times and the relatively short pilot period, the distributor was not promoting the HECUs.

When given the opportunity to provide feedback on the program, neither distributor interviewed had major suggestions. Both felt the incentive values were good and that operations were smooth. Administrative costs do exist though, with particularly high costs and low returns in the startup period for distributors. Participation would thus be a lot more attractive to the distributors during a longer time frame than this short pilot duration. Both distributors also noted that the time they must wait in between submitting the claim and receiving the incentive does impact whether they would participate or not. One listed four weeks as the maximum amount of time they would be willing wait, while the other listed six weeks. While distributors shared in their survey response that they do not anticipate either incentive design will significantly impact customer participation, they both preferred the pass-through. The interviewed contractors preferred pass through as well, with one citing that is much easier to explain to participating parties and much easier to manage. Both distributors also thought the spiffs helped increase sales and both passed the spiffs directly to the salespeople.

Contractor Webinars

Contractor training webinars were held on July 26, 2023, and February 15, 2024, and a copy of the contractor training presentation is found in Appendix K. Survey responses from contractors were minimal and inconclusive. Survey results from distributor interviews (Distributor Interview Results) and site monitoring contractors (Site Monitoring Survey Results) were more conclusive and referenced for program recommendations.

Midstream Pilot Summary

- Three of four enrolled distributors submitted claims during the midstream pilot program.
- All three participating distributors submitted claims for HEEUs only.
- Zero HECUs were incentivized through the midstream pilot.
- 33 HEEUs were incentivized, for an average of $729 each, through the midstream pilot.
- Survey results with distributors imply that an incentive program design with a required pass-through (vs. non-required-passthrough) would not significantly impact customer participation.
- Lack of HECU claims were attributed to limited inventory availability from manufacturers.
- Midstream pilot program length of six months was interpreted as limiting potential participation. A long-term program may increase participation, encourage internal manufacturer and distributor training, and stimulate supply chain investments.
- Survey results with distributors imply that incentive pricing in the pilot was adequate for increasing market adoption rates.
- Midstream pilot program seasonality (Fall 2023 to Spring 2024) was interpreted as likely limiting participation due to lack of coincidence with summer weather and historically peak refrigeration equipment failure season.

Recommendations for Future Programs

- Further efforts are needed to overcome HECU supply chain and manufacturing barriers identified in the project plan and market characterization study.
- Equipment must be installed correctly to enable all high-efficiency features. Contractor education is an important factor in ensuring proper installation of high-efficiency system controls.
- Future program incentive pass-through requirements could be based on implementer preference, speed of reimbursement, and free-rider concerns.
- Spiffs are valuable for distributor participation.
- Removing pilot timeline and distributor limitations from a future program will likely increase uptake in a year-round program. This includes the pilot running during cooler months, outside of the peak season for failure or replacements.

Section 4. Qualified Products List

Objectives

The objective of the QPL is to provide a pre-approved list of rebate-eligible equipment to distributors, contractors, and end-use customers. The QPL provides a source of truth for eligibility and ensures that all parties understand the models that qualify for a rebate.

Methodology and Approach

The initial Qualified Products List was sourced and then reviewed from existing HECU and HEEU rebate program QPLs. Source programs include DTE Energy, Mass Save, and Efficiency Vermont. All existing programs with an HECU QPL limited their compressors to 6.0 HP or less. Additional models were added to the QPL after requests for review from engineering submissions for existing HECU and HEEU programs as well as after manufacturer catalogs were provided and reviewed. Qualifying equipment models include the following features:

- HECUs include features such as:
  - Variable speed condensing unit fans,
  - scroll compressor, and
  - floating head pressure controls
- HEEUs include features such as:
  - Tier 1: EC fan motors and variable speed fan controls
  - Tier 2: EC fan motors, variable speed fan controls, defrost controls, and electronic expansion valve

Rebate pricing structure for HECUs is by compressor horsepower and rebate pricing structure for HEEUs is by fan number and tier:

- HECU rebate pricing
  - Eligible HECUs with compressors up to 3.0 HP will receive a rebate of $400 per HP
  - Eligible HECUs with compressors greater than 3.0 HP will receive a rebate of $200 per HP
- HEEU rebate pricing
  - Tier 1 HEEUs will receive a rebate price of $150 per fan
  - Tier 2 HEEUs will receive a rebate price of $250 per fan

Status

HECU

The current HECU QPL (Appendix L) consists of 2,413 unique models across 14 manufacturers. Figure 7 below shows a breakout of these models by manufacturer and Figure 8 shows a breakout of these models by horsepower. Note that Heatcraft Refrigeration Products is a manufacturer for multiple major brands and the disproportionate count of models in Figure 7 represents the re-branding of similar models. See Appendix L: High-Efficiency Condensing Unit Qualified Products List for a link to the full QPL spreadsheet.

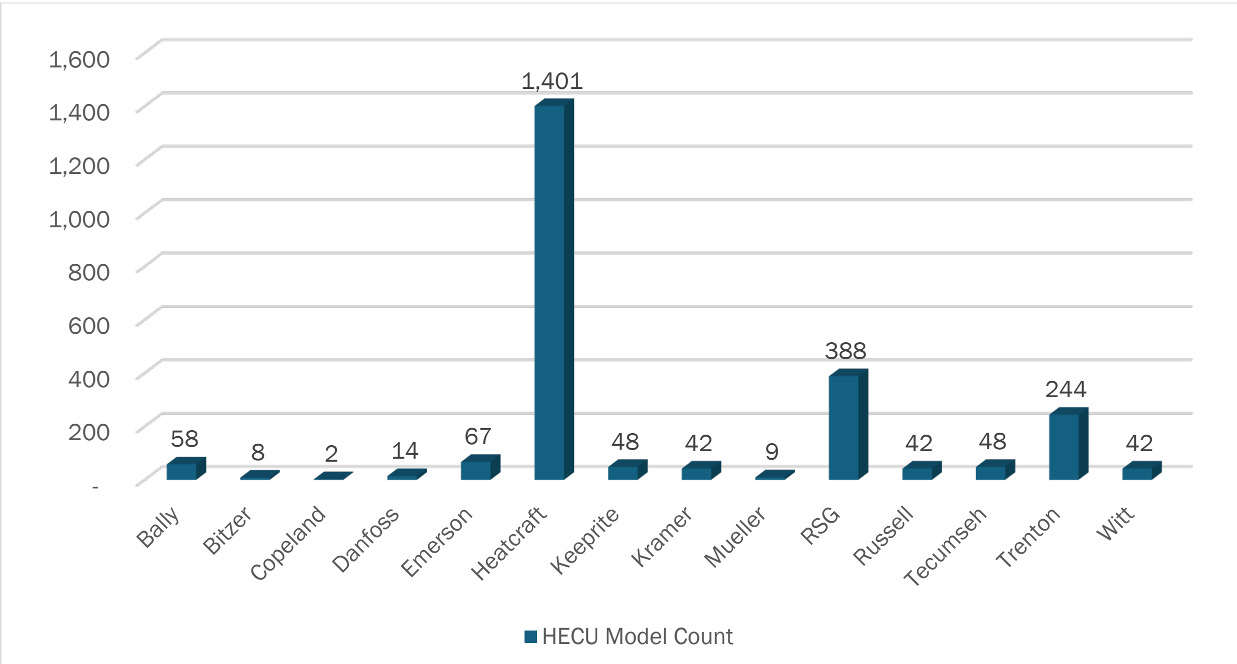

Figure 7: Number of HECU models by manufacturer

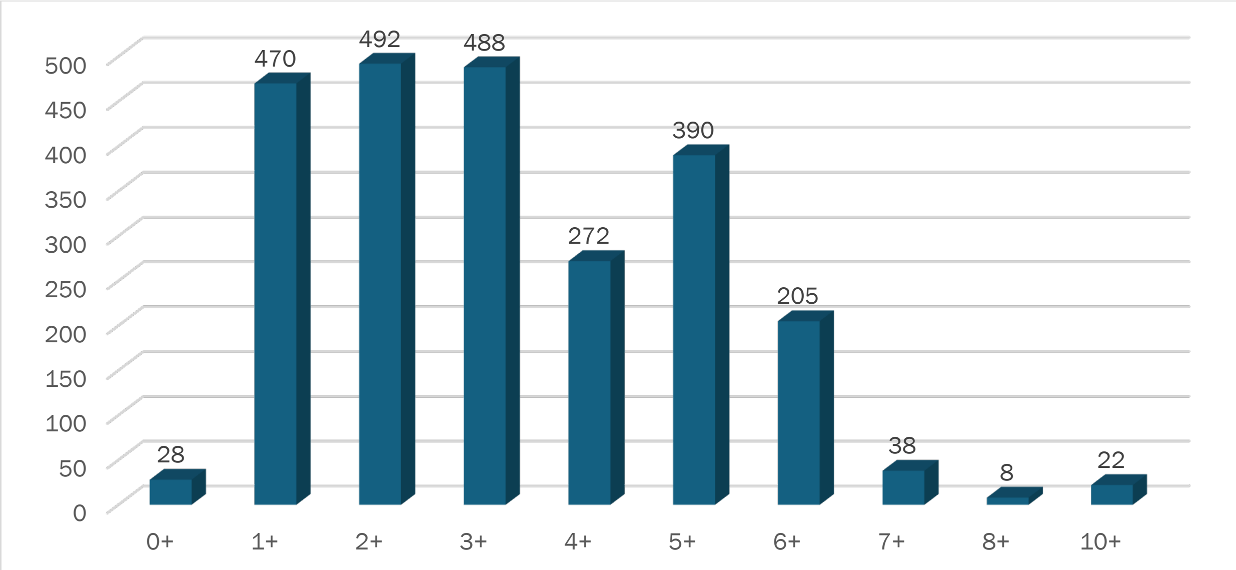

Figure 8: Number of HECU models by horsepower

HEEU

The current HEEU QPL (Appendix M) consists of 1,459 unique models across four manufacturers who produce equipment for seven brands. Figure 9 below shows a breakout of these models by brand and Figure 10 shows a breakout of these models by fan count. See Appendix M: High-Efficiency Evaporator Unit Qualified Products List for a link to the full QPL spreadsheet.

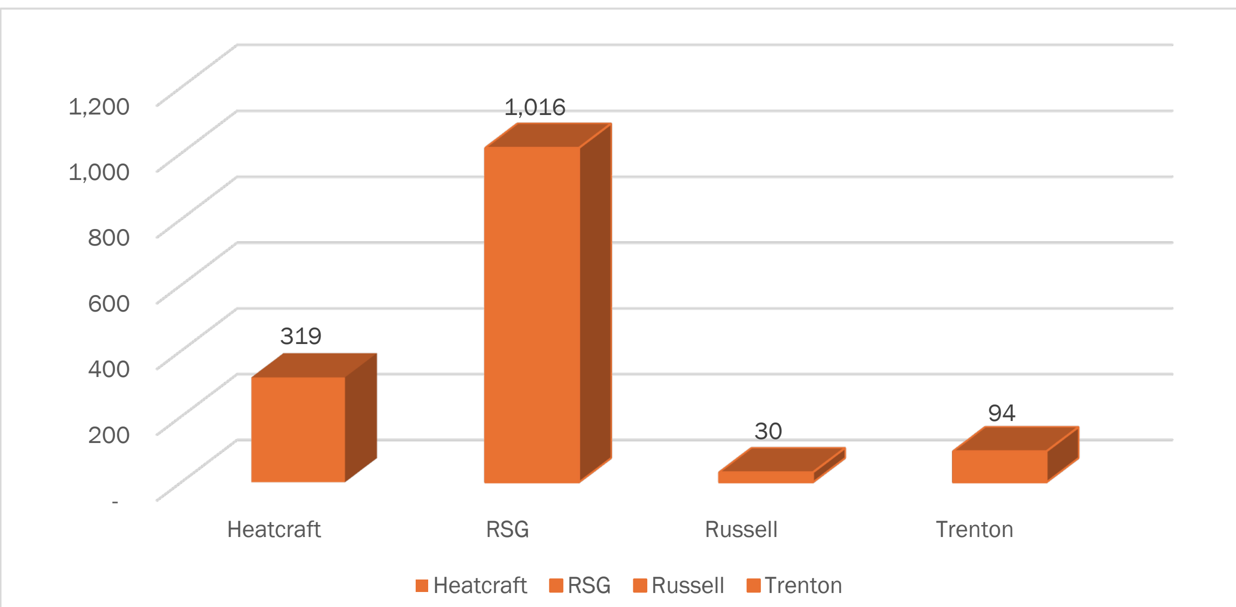

Figure 9: Number of HEEU models by brand

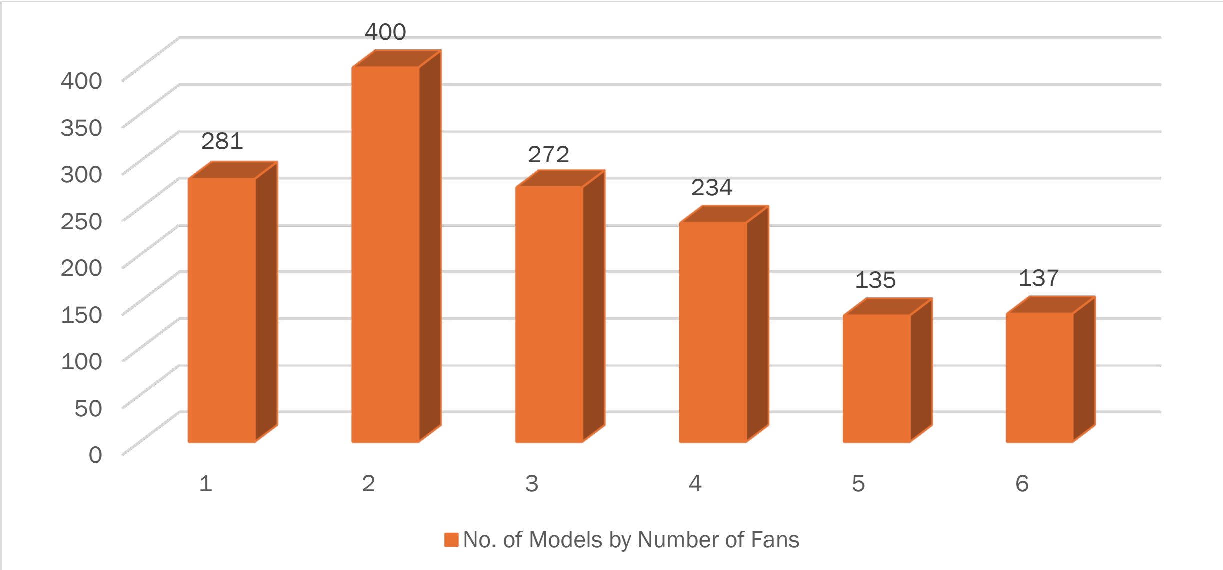

Figure 10: Number of HEEU models by fan count

Low-GWP Package Systems

As a results of on-site monitoring discussions with Hussmann Manufacturing, follow-up discussions with RSG, and both manufacturers' recent releases of air-source, low-GWP, propane-refrigerant (R-290) package cooler and freezer refrigeration systems, the Focused Pilot program has added known low-GWP package refrigeration systems for QPL consideration in a future program. The inclusion of low-GWP package units was unforeseen during the program planning phase. The pilot included a low-GWP air-source packaged refrigeration system in the site-monitoring program and reviewed the efficiency of these package systems as part of the pilot's performance modeling.

The new low-GWP Package Refrigeration QPL (low-GWP QPL, Appendix N) consists of 32 unique models from two manufacturers who produce equipment for three brands. Figure 11 below shows a breakout of these models by temperature application. See Appendix N: High-Efficiency Evaporator Unit Qualified Products List for a link to the full QPL spreadsheet.

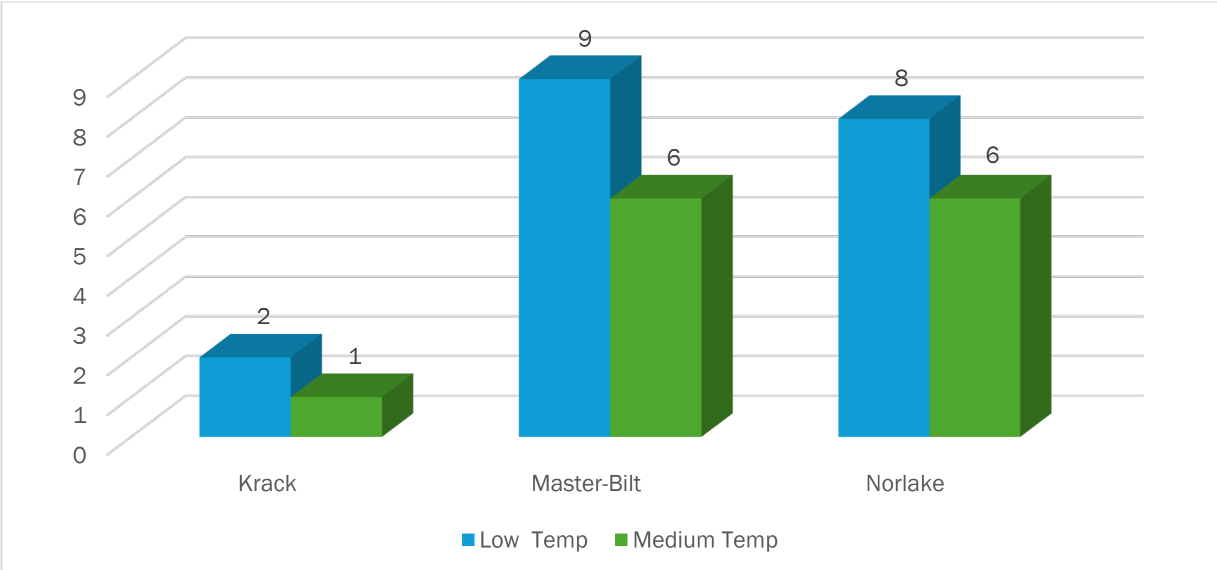

Figure 11: Low-GWP package unit model count by application temperature

Future QPL Considerations

The Focused Pilot expects the QPL to evolve over the coming years. QPL tracking will need to be an active part of any subsequent program. New models are expected to be released to the market throughout the years and additional eligible models and manufactures will be discovered after the pilot. Due to the lack of a regularly maintained list of qualified HECU or HEEU models, such as other equipment or appliance lists such as the ENERGYSTAR® eligible models lists or approved models from California Energy Wise, it is recommended that manufactures are routinely consulted for input on new models that meet the minimum efficiency requirements for an approved measure package.

Section 5. Equipment Energy Regression Modeling

Data Regression Modeling Approaches

1. Linear regression for condensing unit energy normalization: A simple linear regression model was initially employed to normalize condensing unit energy consumption against outdoor temperature. The assumption here is that condensing unit energy use is strongly correlated with outdoor air temperature, and normalizing for this variable would allow for a more accurate comparison between baseline and retrofit periods.

$$y = \beta 0 + \beta 1 \times \text{Outdoor Temperature}$$

where y represents the condensing unit energy consumption, and β0 and β1 are the model coefficients.

2. Multiple linear regression for indoor and outdoor temperature normalization: A more comprehensive modeling approach involved multiple linear regression, incorporating both indoor and outdoor temperatures as predictors of condensing unit energy consumption. This approach was particularly useful in cases where indoor temperature variations also influenced energy use.

$$y = \beta 0 + \beta 1 \times \text{Outdoor Temperature} + \beta 2 \times \text{Indoor Temperature}$$

where y represents the condensing unit energy consumption, and β0, β1, and β2 are the model coefficients.

3. Piecewise linear modeling — handling outliers and operating ranges: In scenarios where condensing unit energy consumption data fell outside the expected minimum and maximum operating ranges, a piecewise element was added to the models. This modification ensured that the model output remained within realistic bounds by setting a constant value for any predicted condensing unit energy consumption that was beyond the expected range, e.g., as limited by a 100-percent duty cycle, which prevented the models from generating unrealistic estimates, particularly under extreme temperature conditions where the linear assumptions may not hold.

Regression Model Selection and Validation

Model fit and selection: After developing both the linear and multiple linear regression models for each site, the best-performing model was selected based on the available data and model fit metrics, e.g., R-squared, mean squared error. This selection process ensured that the most accurate and reliable model was used for subsequent energy performance projections.

Validation: The selected models were validated using the test data, ensuring that they performed adequately under different conditions.

Projection of Yearly Energy Consumption

Climate zone analysis: To estimate yearly condensing unit energy consumption across different climates, the selected models were applied to typical meteorological year (TMY) data from California's 16 climate zones. This dataset, provided by ASHRAE, represents average weather conditions for each zone and allowed for the extrapolation of energy performance to different geographic areas.

Yearly estimates: The model outputs were used to project annual energy consumption for each site in each climate zone, providing a comprehensive understanding of how the retrofitted systems would perform under varying climatic conditions.

Evaporator Energy Normalization

Averaging method: Unlike the condensing units, evaporator energy consumption was found to be relatively unaffected by outdoor temperature fluctuations. As a result, the average evaporator energy consumption over the entire monitoring period was calculated for both the baseline and retrofit periods.

Integration with condensing unit energy: The averaged evaporator energy was added to the normalized condensing unit energy consumption to obtain the total system energy consumption for each site. This combined metric was used for final comparisons between baseline and retrofit performance.

Total System Energy Comparison

Comparison and analysis: The total system energy consumption — comprising both normalized condensing unit and averaged evaporator energy — was compared between the baseline and retrofit periods. This comparison highlighted the energy savings achieved through the retrofit measures.

Reporting: The results shown in Appendix J: Site Monitoring Summary Data were reported for each site and climate zone, providing insights into the effectiveness of the retrofits and the potential for energy savings across different environmental conditions.

Section 6. Measure Package Development Preparation

The data prepared in this report has provided the basis for developing a measure package in the California eTRM. Additional analysis may be required to validate and aggregate the data into a format for the eTRM, but the project has provided the foundational data needed to develop measure packages for high-efficiency condensers and evaporators.

The data from the project — including the original metered, interval data, analysis spreadsheet, and supporting data — will be packaged for ease of use and future analysis. Measure developers will have access to all data required to fully draft a measure and identify any future measure development needs.

Measure development will require the submittal of a measure package proposal to the California Technical Forum, (Cal TF), drafting of a measure characterization including the methodologies and formulas used to calculate the savings, development of the measure package content in the eTRM, review from Cal TF, final submittal of a measure package plan, and review by the CPUC.

Conclusion: Key Findings

- The market is susceptible to market transformation interventions addressed in the Focused Pilot.
- The market is responsive to interventions targeting adoption barriers and the accelerated adoption of HECUs and HEEUs.
- Normalized and averaged energy analysis from the Site Monitoring Pilot shows reduction in yearly energy for retrofitted HEEU and HECU systems.
- A program delivery model that incentivized distributors to increase stocking of high-efficiency equipment for as-fails replacement scenarios would assist in overcoming supply chain barriers that limit HECU and HEEU adoption.
- Distributor sales representatives are key market actors and are well positioned to be the drivers for educating contractors and suggesting comparably sized and incentivized high-efficiency refrigeration models at the time of equipment price quotes or ordering.
- Distributor participation and satisfaction in a point-of-sale HECU and HEEU incentive program are dependent upon timely distributor incentive reimbursement.
- Contractor education on high-efficiency features, incentives, correct installation, and correct operation is integral to increasing adoption and realizing the energy savings associated with the purchase and install of HECUs and HEEUs.
- Midstream Pilot distributor feedback indicated that HECU adoption and participation was limited by equipment availability from manufacturer; further outreach and partnership with distributors and their direct suppliers and manufacturers is needed to increase distributors' HECU inventories to be on par with the existing HEEU inventories.
- A long-term incentive program with an advertised incentive pass-through would enable a program to openly market full incentives applying equally to all participating distributors, contractors, and end-use customers.
- A new measure that incentivizes end users would assist in overcoming first-cost barriers for HECU and HEEU adoption. The pilot team recommends a new measure package be developed and submitted.

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Appendix A: Blueprint

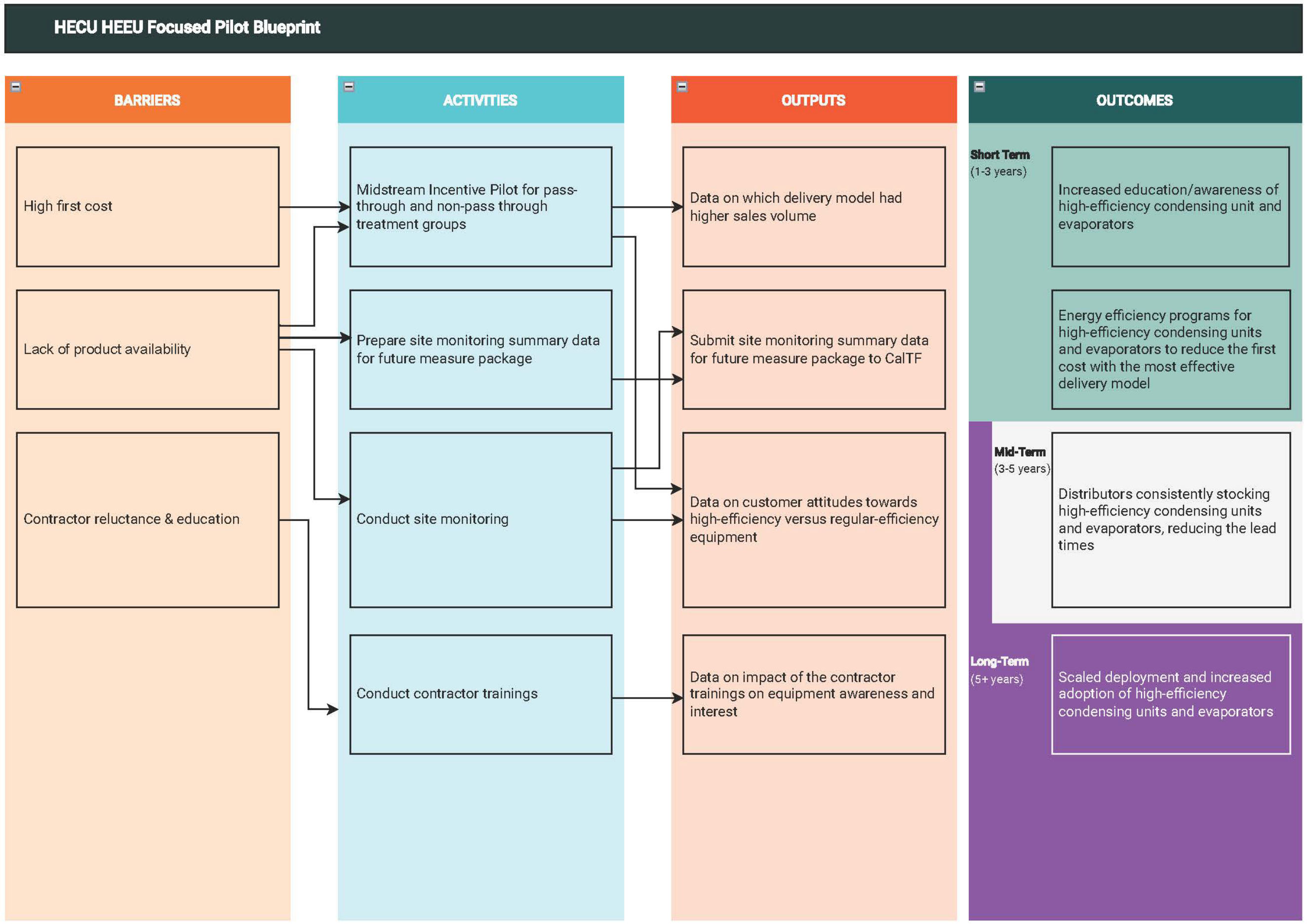


Figure 12: HECU HEEU Focused Pilot blueprint

Appendix B: Program Comparison Table

Table 29: Incentive Program Comparison

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
Michigan	Michigan Saves	ECM motors for refrigeration cases	Not listed	From website: "Michigan Saves partners with DTE, Consumers Energy, and SEMCO to get you the lowest interest rates out there for your efficiency projects. Qualifying commercial and municipal customers could receive as low as 0% APR for eligible improvements"
		Efficient refrigeration condenser	Not listed	
		Floating head pressure control	Not listed	
		Walk-in cooler or freezer ECM	Not listed	
	DTE	Evaporator controls with demand defrost for walk-in coolers or freezers	Controls must have adaptive learning via a micro-processor or web-based controller. Control of the defrosting system is based on demand-initiation of defrost cycle. Manual control (always on) of evaporator fans does not qualify. Temperature in coolers must range from 33–50°F and temperature in freezers must range from 0–32°F.	N/A
		ECM for reach-in refrigerated display case	Retrofit of existing refrigerated display cases with an ECM (electronically commutated motor) replacing an existing standard efficiency shaded pole (S-P) or permanent split capacitor (PSC) evaporator fan motor.	$45 per HP

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
		Evaporator fan motor control for walk-in cooler or freezer	Incentives are available for controllers that lower fan airflow and reduce motor power consumption by at least 75% during compressor off cycles. Each controller must control at least two evaporator fan motors with motor sizes of 1/20 HP or larger. Motor types must be ECM or PSC motors. Eligible for new construction ECM motor types only.	$75 per HP
		Walk-in and case cooler permanent magnet synchronous motor	Applies to replacement of existing standard efficiency shaded pole, permanent split capacitor evaporator or electronically commutated motors (ECM). The replacement must be a permanent magnet synchronous motor (PMSM). Permanent magnet synchronous motors installed in new walk-in or case coolers do not qualify. This measure is intended for grocery stores, convenience stores, restaurants, deli, health care, and academia that use refrigeration equipment.	N/A

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
		Floating head pressure controls	Incentives are available for installing automatic controls to lower condensing pressure at lower ambient temperatures in multiplex refrigeration systems. Controls installed must vary head pressure to adjust condensing temperatures in relation to outdoor air temperature. The controls must replace existing constant pressure or manually controlled systems to achieve lowered head pressure to maintain a minimum saturated condensing temperature of 70°F, or a 20°F variance below design head pressure during mild weather conditions.	$50 per ton
		HECU/HEEU	Valid zip code in DTE territory and installed equipment is listed on DTE's QPL.	HEEU per fan: tier 1 $150 per fan, tier 2 $250 per fan HECU per HP: tier 1 $400 per HP for 1-3 HP, tier 2 $200 per 3-6 HP
Massachusetts	Mass Save	HECU	Must be an existing customer of Cape Light Compact, Eversource, National Grid, or Unitil. Qualifying equipment must be purchased from a participating commercial kitchen equipment dealer or HVAC distributor for HECUs	up to $1200 per unit incentive
Colorado	Xcel Energy	ECMs for Reach-In Cases	Existing business electric and/or	$40 per unit

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
		ECMs for Walk-in coolers and freezers	retail gas customer of Xcel Energy in Colorado.	$70 per unit
		Floating head pressure control		Low-temp $50 per ton, high-temp $25 per ton
		Walk-in freezer defrost controls		$130 per 1000 watts controlled
		Custom efficiency program	Submit the Customized Solutions application prior to equipment order and be an Xcel Energy electric and/or gas business customer	Rebates up to $500 per system peak demand kilowatt (kW) of electricity saved, plus $100 per non-peak demand kilowatt in excess of system peak demand kilowatts saved
	Black Hills Electric	Custom electric commercial rebate program	Custom rebates to encourage commercial and industrial customers to replace similar, less energy-efficient equipment.	50% of the incremental cost, incentive per kilowatt hour
	United Power	Refrigerated case or walk-In cooler fan motor retrofit	Replacement of evaporative fan motors with Electronically Commutated Motors (ECM) in existing cases or in new cases installed in an existing store or location. Medium- and low-temperature reach-in refrigerated cases, multi-deck open cases, and walk-in coolers. One project per member-owner account location per year.	$50 per unit

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
Oregon	EPUD	Custom commercial incentive program	Custom energy-efficiency projects with verifiable electric energy savings, including large projects for commercial, industrial, and agricultural customers.	Rebates are determined based on actual energy savings up to $0.18 per kWh and cannot exceed 50% of the total project cost.
	Idaho Power Co.	Refrigerated cases	Concurrent changes to the cases, including electronically commutated motor (ECM) upgrades.	$200 per motor
		Custom commercial projects	Custom incentives are available for all commercial or industrial customers, refrigeration equipment included	Idaho Power offers a custom incentive of $0.18 per kWh saved, up to 70% of the eligible cost
Washington	Avista	Custom commercial projects	custom Incentives are available for many energy-efficiency projects that fall outside the parameters of our other prescriptive programs which result in verifiable energy savings. Incentives do not apply to behavioral modifications. The incentive is based on the first-year energy savings (either in kilowatt-hours or therms).	Minimum measure life of 10 years to under 15 years $0.23 cents per first year kWh saved)

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
	Tacoma Power	Custom projects, includes efficient commercial refrigeration evaporators and condensers	The existing commercial, industrial, or governmental building must be within Tacoma Power's service territory. Not available for new construction. All projects must be approved by Tacoma Power before equipment is installed.	Incentive rate is 23 cents per kilowatt hour saved in the first year, up to 70% of the total approved project cost
Maine	Efficiency Maine	HEEU fan motors, walk-in coolers and freezers	N/A	$50 per motor
		HEEU fan motors, refrigerated warehouses	N/A	$100 per motor
		HEEU fan motors–merchandise cases	N/A	$20 per motor
		Evaporator fan motor controls	N/A	$250 per controller
		Floating head pressure controls–1 coil	N/A	$250
		Floating head pressure controls–2 coils	N/A	$375
		Floating head pressure controls–3 coils	N/A	$500

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
New York	RGE/NYSEG	Electronically commutated motors (ECM) for refrigeration evaporator fans	Pertains to the replacement of single-phase shaded pole or permanent split capacitor (PSC) evaporator fan motors with electronically commutated motors (ECM) in walk-in and reach-in refrigerated cases. ECM must be replacing shaded pole or permanent split capacitor motors in a refrigerated case or walk-in cooler/freezer. Must be a one-for-one replacement, both in quantity and in horsepower. Existing equipment to be replaced must have been manufactured before January 1, 2009. If horsepower, quantity, or phase differs from the existing equipment, submit for a custom rebate	$20 per motor

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
		Evaporator fan controls	Pertains to the installation of fan controls on electronically commutated or shaded pole evaporator fan motors in walk-in coolers and freezers. Acceptable controls include on/off or multispeed which allow for the modulation of evaporator fans, reducing fan speed or turning them off when the compressor is not running. For cooler/freezer spaces storing perishable food product, the cooler/freezer space should be tested to avoid hot spots away from thermostat during low-speed fan operation.	$20 per motor controlled
Pennsylvania	First Energy	Custom equipment program	Custom projects include building shell, electrical and mechanical improvements that reduce energy consumption and demand by improving building energy performance.	Incentives are paid at 5¢ per kWh for retail energy usage displaced from FirstEnergy's Pennsylvania utility distribution system and up to $150/kW for demand reduction during the period of June 1–August 30, M–Fr, 2–6 pm (excludes holidays and weekends). Incentives are capped at 50% of total project cost, up to $500,000.

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
Maryland	SMECO	ECM evaporator fan motor	Applicable to the replacement of an existing standard efficiency shaded-pole evaporator (SP) or permanent split capacitor (PSC) fan motor in refrigerated walk-in or reach-in boxes (coolers or freezers). The replacement unit must be an electronically commutated motor (ECM)	$50 per motor
		Custom commercial program, includes floating head pressure control	To be eligible for incentives, custom projects must produce energy savings.	Financial incentives can cover up to 50% of the total cost for retrofit projects or up to 75% of the incremental cost for replacing old equipment.
	BGE	ECM evaporator fan motor	Applicable to the replacement of an existing standard efficiency shaded-pole evaporator (S-P) or permanent split capacitor (PSC) fan motor in refrigerated walk-in or reach-in boxes (coolers or freezers). The replacement unit must be an Electronically Commutated Motor (ECM).	$50/motor
		Networkable evaporator fan controls	Savings are achieved by reducing the speed of the evaporator fans on refrigerator cooler and freezer cases by at least 75% for an ECM, and 100% for non-ECM when compressor not running	$75 per existing shaded-pole motor $65 per existing ECM motor

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
Indiana	Duke Energy	Walk-in cooler and freezer - ECM replacing permanent split capacitor	Replacement must be expected to result in energy savings to qualify. Equipment required to meet applicable energy codes is not eligible. Equipment must be served by Duke Energy electric service and installed in customer's facility.	$10 per 0.01HP
		Walk-in cooler and freezer, ECM replacing shaded pole		$11 per 0.01HP
		Refrigerated or freezer display case - ECM replacing permanent split capacitor		$10 per 0.01HP
		Refrigerated or freezer display case, ECM replacing shaded pole		$11 per 0.01HP
		Floating suction pressure controls		$14/HP
Illinois	WVPA	Custom project	Projects must follow basic POWER MOVES® specifications as listed in the other applications and based on the type of custom project. Unclear if refrigeration related projects qualify,	Non-lighting projects are calculated using $08/kWh saved in the first year
	ComEd	EC motor for walk-in cooler or freezer	Replacement unit must be an electronically commutated motor with a minimum efficiency of 66%.	$60 per motor

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
		EC motor for reach-in refrigerated case	New walk-in or reach-in coolers and freezers with integrated EC motors do not qualify for this incentive. This measure cannot be used in conjunction with evaporator fan controls measures. Replacement of an existing, uncontrolled, continuously operating, standard-efficiency shaded-pole evaporator fan motor with an electronically commutated (EC) motor.	$30 per motor
		EC motor with evaporator fan controls for walk-in cooler or freezer	Must control a minimum fan load of 1/20 HP where the fan(s) operate continuously at full speed. Must reduce fan motor power by at least 75% during the compressor off-cycle. This measure is not applicable if any of the following existing (base case) conditions apply: (1) The compressor runs all the time with high duty cycle. (2) The evaporator fan does not run at full speed all the time. (3) The evaporator fan motor runs on poly-phase power. d. The evaporator does not use off-cycle or time-off defrost.	$90 per controlled motor
		Evaporator fan controls on EC motor		$50 per controlled motor
		Demand defrost controls	Installation of defrost controls that monitor the refrigeration system and delay the defrost cycles, as necessary.	$20 per evaporator fan motor

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
		Efficient refrigeration condenser	The new condenser must result in at least 85 Btu/hr of heat rejection per watt of fan power for air cooled condensers. For evaporative-cooled equipment, a minimum of 195 Btu/hr per watt is required. New condenser must be more efficient than condenser being replaced.	$10 per ton
		Floating head pressure controls	Controls must vary head pressure to adjust condensing temperatures in relation to outdoor air temperature. Must replace existing constant pressure or manually controlled systems to achieve reduced head pressure to maintain a minimum saturated condensing temperature of 70°F, or a 20°F variance below design heat pressure during mild weather conditions. Compressors must be 1HP or greater. A photo confirming the compressor HP must be submitted along with the pre-application.	$60 per compressor HP
		VSD for condenser fans	Measure is applicable to VSDs installed on condenser fan motors operating in refrigeration systems. New motors installed without a VSD qualify for this measure. Existing motor load must operate at fixed speeds. Motors must be 0.5-1.5 HP. 5. Screenshots of the control system sequence may be requested.	$150 per HP

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
Iowa	MidAmerican Energy	Custom program	Participants must be nonresidential customers (commercial or industrial) with facilities located in MidAmerican Energy Company's Iowa service territory. Customers may not receive custom rebates in lieu of prescriptive rebates or instant discounts.	0.08-$0.12 per kWh of first-year savings or the lesser of the calculated custom rebate or 50% of the eligible project cost.: Custom rebates are limited to $100,000 per project.
Vermont	Efficiency Vermont	HECU	Qualifying models are on EVT's QPL and must be between 0.5 and 6 horsepower nominal output. Condensers must have a scroll compressor. Must include floating head pressure controls which modulate condenser fan speed. Examples of this include the Limitrol and Orbus controllers. Condensers must be certified for outdoor installation.	$600/HP for units < 4 HP $400/HP for units >= 4 HP Up to $2,400 per unit
		High-efficiency evaporators	Qualifying models are medium- and low-temperature evaporators on EVT's QPL with fan motors ≤ 1/15 horsepower that contain the following components: EC motors Integrated motor controls Electronic Expansion Valve (EEV) Integrated controls which optimize defrost	$250 per fan, up to $1,500 per unit

State	Utility or Program	Measure	Eligibility Criteria	Incentive and/or Rebate
Rhode Island	Rhode Island Energy	Custom program	Eligibility check with RI Energy required before custom project application submission. Minimum requirements for equipment determined on a project specific basis.	N/A
New Hampshire	NH Saves	Custom program	All Custom projects require a detailed engineering analysis to determine project savings. Only projects that pass a utility benefit to cost (B/C) test will be eligible for an Incentive	N/A
	Eversource	N/A	Custom Program but does not appear commercial refrigeration measures qualify.	N/A

Appendix C: Market Actor Interview Guides

Market Actor Interviewee: Utility Program Manager

Information Goals

- Best practices and key barriers to program design and implementation of HECU and HEEU
- Characterization of application and installation practices of HECU and HEEU
- Key market actors and their influence on the program
- Program metric and evaluation data for incentive structure, participation numbers, savings claims, and measure characterization

Contact Information

- Interviewee Name:
- Interviewee Title:
- Interviewee Company and Role:

Program Design and Impact Questions

- What were the drivers that prompted the creation of the program?
- When was the program first launched?
- What audience does this program target?
- How has the program scaled since launch? Are you observing market transformation? How has the adoption levels and participation numbers changed year over year?
- How do you measure the success of the program?

Key Market Actor Questions

- Can you explain key stakeholders in the program implementation process and describe their roles and responsibilities?
- What has your outreach and marketing activities been?
- How has the engagement gone across the supply chain with manufacturers, distributors, contractors, and business owners? Was there a training element to participation and if so, can you describe it?
- What is the break-down of building types and installation applications? Is it mostly supermarkets or a range between them, restaurants, hospitals, etc.

Best Practices and Key Barriers Questions

- What were some of the key barriers you had to overcome to have a successful program?
- What were some of the lessons you learned along the way? What were some of the key takeaways?
- What advice would you give to California before launching a similar program?
- What motivates customers to participate in this program and install this equipment?
- What are some key barriers to customers participating in this program?
- Lack of awareness/familiarity with the equipment?

- Performance concerns or misperceptions?
- Incentive amount was too low?
- Preference for other equipment?
- Supply/availability?
- Cost-effectiveness challenges?

Program Theory and Logic Model

- What are the incentive structures for this equipment?
- What is the participation process for this program?
- What is the program delivery and logic model? (midstream, downstream, etc.)
- What is your annual program budget?
- How many HECUs and HEEUs have you incentivized? (i.e., what have the participation rates been for the program over the stretch of its life?)
- Has the program been evaluated, and if so, can you share the results?
- What are your savings claims?
- Can you share other program data such as cost-effectiveness, incremental costs, measure lives, savings, etc.?

Regulatory Questions

- How does the policy landscape influence the design and implementation of the program?
- How does federal and state codes and standards impact this?
- Do you have to work with and engage local regulatory agencies on commercial refrigeration equipment?
- What key programmatic changes have you made? What prompted you to make these changes?

Low-GWP Refrigerant Equipment Questions

- Does the program claim additive savings (kWh or otherwise GHG savings) for low GWP refrigerant options?
- If the answer is *no*, is there consideration for adopting this into the program in the future?
- If the answer is *yes*, does the program offer additive incentives for low GWP refrigerant options?
- What percent of the available equipment in the market would you estimate to be low GWP options?

Wrap Up Questions

- Are there other best practices for the launch of this program and engaging the supply chain that would help California launch this program?

Market Actor Interviewee: Distributors

Information Goals

- Knowledge, perception, market trends, and experience with HECU and HEEU
- Characterization of application and installation practices of HECU and HEEU
- Federal and state code considerations associated with the measures
- If available, sales and pricing number of HECU and HEEU

Contact Information

- Interviewee Name:
- Interviewee Title:
- Interviewee Company and Role:

Market Characterization and Sales Questions

- How many condensing units and evaporator units do you sell in a year? What percentage of your business is due to the sale of this equipment?
- Who are you primarily selling equipment to? Contractors? Direct to business owners?
- Would you have a breakdown of building types that your equipment is sold to? Grocery store, convenience stores, restaurants, schools, etc.?
- Are you familiar with and what are your general thoughts on HECU and HEEU?
- If has no knowledge or unsure of what you're asking about: Describe the HECU and the HEEU product and the motivation behind it.
- If has knowledge: Ask them to define the product, if they stock it, and confirm they have a good understanding of it.
- Of the percentage of units sold last year, how many would fall under the definition of HECU and HEEU? Or are these something you do regularly keep in stock?
- What are the predominant brands and makes of condensing units and evaporator units sold in California? Would you have an estimate on that market share? What manufacturers do you primarily procure and stock equipment from?

Best Practices and Key Barriers

- Do you see any potential applications for HECU and HEEU and where do you think they can best be used?
- Do you see any applications where these would not be a good fit?
- Do you see any barriers that would prevent you from selling or from customers installing this technology? (Probe for market availability, lack of education and knowledge, etc.)
- Are certain efficiency features harder to sell? Do you receive customer feedback on major hurdles to adoption of these technologies?
- Is cost a barrier for customers on installing HECU and HEEU? Can you estimate the difference in costs between an HECU and HEEU against their less energy-efficient counterparts?
- Are there any permitting concerns surrounding installing this type of commercial refrigeration equipment? If so, could you please explain them?

EE Program Design Questions

- How does your company typically promote and market commercial refrigeration equipment?
- What percentage of customers ask about HECU and HEEU versus you being the first one to mention the availability of the high-efficiency equipment?
- Have you had any interactions with, or are you familiar with, the EE programs operated by the California IOUs? If they ran a program incentivizing HECU and HEEU, would you be interested in participating?
- If there is familiarity with existing utility incentives, how has the availability of utility incentives impacted your sales or the stocking of high-efficiency refrigeration equipment in California?
- Do you have thoughts or estimates on a potential rebate that might be applied and where in the supply chain it would make the most impact?
- When launching this program, do you have any suggestions or best practices that you have seen in other territories that you would recommend?

DAC/HTR Community Questions

Hard-to-reach-customers, by CPUC definition, do not have easy access to energy-efficiency program information or generally do not participate in energy-efficiency programs and who satisfy the criteria below by either (1) satisfying the Geographic Criteria (as defined below) and one additional criterion, or (2) satisfying three of these four criteria:

- A customer whose has a language barrier and whose primary language spoken is a language other than English
- A customer with a **geographic barrier** (i.e., businesses or homes in areas other than the United States Office of Management and Budget Combined Statistical Areas of the San Francisco Bay Area, the Greater Los Angeles Area and the Greater Sacramento Area or the Office of Management and Budget metropolitan statistical areas of San Diego County) or is located in a Disadvantaged Community (this is the "Geographic Criteria");
- For small business, additional criteria include:
- A business size that is less than ten employees or classified as very small (i.e., customers whose annual electric demand is less than 20 kilowatts (kW), or whose annual gas consumption is less than 10,000 therms, or both)); and
- A business that leases or rents the facilities in which the energy-efficiency investment will be made.
- For residential, additional criteria include:
- Customers whose income is such that they qualify for the California Alternative Rates for Energy (CARE) or the Family Electric Rate Assistance (FERA) Program
- Customers who reside in a multi-family home or a mobile home and who either rent or lease such residence.

Please keep in mind that not all DAC areas should be considered de facto low-income areas, and vice versa, HTR and LI exist in non-DAC areas. When speaking to survey participants such as manufacturers and distributors, if asked what we mean by DAC, it might help to limit the response to "communities disproportionately burdened by multiple sources of pollution."

- Do you segment your customers in California? If so, what are those segments, and do they include DAC/HTR communities and national chain customers?
- Do you actively market to DAC/HTR communities? If so, is it any different to how you market to non-DAC/non-HTR businesses, organizations, or communities?
- Do you monitor and track purchasing habits, trends, and barriers or customer segments/types? If so, what have you noticed?
- Do you know, or perceive, that there are similarities and/or differences in the above areas between DAC/HTR communities and those that are not?
- Do you stock different quality/grades of condensing units and evaporator units to cater to lower income/disadvantaged communities relative to the broader market?

Low GWP Refrigerant Equipment Questions

- Do you stock low GWP refrigerant equipment?
- Do you have customers asking about low GWP refrigerant equipment options?
- Do you sell low GWP refrigerant HECU and HEEU? What percentage of sales would this account for?

Wrap Up Questions

- What trends do you expect to see in condensing unit and evaporator unit sales in California over the next 10 years?

Appendix D: On-Site Monitoring Marketing Pilot Program Collateral

Stipends for purchase & installation of high-efficiency condensing and evaporator units. Limited participation slots available.

How It Works

1. **Confirm old, existing equipment is functional.** Existing walk-in cooler and freezer refrigeration equipment must be functional to participate in monitoring by CalNEXT Walk-in Monitoring Pilot Program.
2. **Verify location eligibility.** Participating equipment must be installed in a non-residential location that receives electricity service from a California investor-owned utility. Use the easy ZIP code look-up tool to verify install address eligibility at caenergywise.com/instant-rebates/#customer-eligibility.
3. **Submit nomination form.** Participants must complete a nomination form to be considered. Details about existing walk-in equipment and business operating hours are among the questions required for nomination. Your CalNEXT team member will provide, review, and submit nomination forms.
4. **Get selected.** Applications will be reviewed and selected based on program requirements. Businesses are not eligible for equipment stipends prior to being selected.
5. **Existing equipment monitoring.** Once selected, we will arrange for your existing equipment to be monitored for at least two weeks before being removed and replaced. Monitoring equipment is small and out of sight. It's business as usual until your new equipment is installed!

Continued on next page

Participation Benefits

Stipend towards purchase of high-efficiency cooler and freezer refrigeration equipment.

Up to 100% of costs eligible. Labor costs included.

Replace your old, inefficient refrigeration equipment and save money on electric bills every month!

Provide your input on future rebates for this equipment throughout the state.

Questions?
Contact Energy Solutions at 510.482.4420 x569 *or* rsucato@energy-solution.com

Figure 13: On-site monitoring collateral — front

CalNEXT

Walk-in Monitoring Pilot Program

6. **Verify equipment eligibility.** The CalNEXT team will provide you with a list of eligible high-efficiency condensing and evaporating units.

7. **Purchase and install new equipment.** Once the monitoring team gives the "okay," you can purchase eligible equipment for installation from your preferred supplier and select a licensed refrigeration technician for installation and commissioning. The CalNEXT team will make sure to coordinate weeks in advance so you can choose an installation time that is best for your business. Once installed, our team will arrange to monitor your new system for at least two weeks.

8. **Submit for stipend.** Equipment is eligible for stipend upon completion of post-installation monitoring and participation in the program survey.

9. **Back to business.** Once your equipment is installed, you are back to business. Enjoy years of energy savings with your new equipment, and know your contributions will help shape potential incentive programs for you and your peers.

Stipend Amounts

Up to $15,000*
in stipends available per site

100%†
of parts and labor are eligible

* Stipend amounts not to exceed total cost of installation.

† Equipment and installation costs exceeding $15,000 are to be covered by participants.

This pilot is part of the CalNEXT emerging technologies program. For more information on CalNEXT visit calnext.com.

Pilot Duration

This is a short-term monitoring project—scheduled to operate for six months, from March 15, 2023 through September 30, 2023. New equipment must be installed by September 1, 2023. The purpose of the project is to collect on-site data on energy use of this high-efficiency equipment to inform future incentive programs in California.

Condensing Unit Requirements

- ☑ Floating head pressure controls
- ☑ Modulating speed condenser fans
- ☑ Scroll compressor or variable speed reciprocating compressor

Evaporator Unit Requirements

- ☑ EC motors, Integrated motor controls
- ☑ Optional: Electronic Expansion Valve (EEV), Integrated controls to optimize defrost

Other Details

- ☑ Walk-in coolers or walk-in freezers are eligible. Submit both to double your selection chances!
- ☑ Condensing units and evaporator units must both be replaced.
- ☑ Condensing units may not exceed 10 horsepower.
- ☑ Rack-style refrigeration systems are not eligible for the monitoring pilot.

Figure 14: On-site monitoring collateral — back

Appendix E: On-Site Monitoring Nomination Form

ENERGIZING CALIFORNIA'S FUTURE

CalNEXT HECU/HEEU Pilot - Site Monitoring Nomination Requirements & Questionnaire

Onsite Monitoring Summary

Onsite equipment monitoring will be conducted for approximately 10-15 projects to obtain data on field operation and used to understand and quantify energy savings resulting from high-efficiency equipment installations.

Projects will be selected for monitoring that are representative of the key customer types and climate zones for this type of equipment in California. Onsite monitoring equipment will be installed by the focused pilot team and monitoring will include both pre- and post-installation collection periods to collect both baseline and new equipment data points.

Sites will be recruited by the focused pilot team and a customer agreement will be developed for each selected project. Customers will be responsible for installing high efficiency condensing units and evaporators at the selected sites according to all applicable licensing and permitting requirements.

Data from facility energy management systems (EMS) will be collected and utilized if available. Primary data to be collected includes refrigerant type, ambient dry bulb temperature, voltage, amperage, measured kW, and operating hours.

In exchange for permission to conduct onsite monitoring, EMS data sharing, interviews with key contacts, and access to meter data (if possible), the pilot program will cover the full cost of equipment and installation, up to $15,000 per project. The monitoring will follow CA Monitoring & Evaluation Protocol set by the CPUC. Participating customers and installation contractors will be required to participate in a survey and/or interview to document purchasing habits, project barriers, satisfaction with equipment, interest in energy and GHG saving features, and use of new equipment temperature controls as part of the monitoring project.

Site Selection Requirements

Each partner in the HECU/HEEU Pilot Project (the Project) are required to submit at least three (3) vetted locations for potential walk-in cooler or freezer (WICF) high-efficiency condensing unit (HECU) and/or high-efficiency evaporating unit (HEEU) replacement. Selected sites are eligible for a stipend of up to $15,000 to cover qualified parts and labor.

Location nominations are encouraged to be submitted as discovered and at least three (3) nominations are required to be submitted to Program Administrator (Energy Solutions) by April 20, 2023.

Preferred sites will meet the following criteria:

- Location of equipment installation must reside within a ZIP-Code covered under existing California Electric Foodservice Equipment Incentive Program. Use the easy ZIP Code look-up tool to verify install address eligibility at www.caenergywise.com/instant-rebates.
- Location of installation must provide program partners access for data logging purposes for at least two (2) weeks before installation and at least two (2) weeks after installation.
- Existing WICFs must not have additional equipment or use changes during the monitoring period. All WICFs are to use the same shelving, gaskets, air sealing, door latches, flooring, insulation, lamps, use patterns, etc. during the monitoring period.
  - o High-efficiency replacement equipment is not required to use the same refrigerant type and may be replaced with a lower GWP refrigerant.
- Existing systems must be under 10 horsepower.
- Preferred systems will have a full system replacement (condensing unit and evaporating unit)

Onsite Monitoring Nomination Questionnaire

Partner Organization Nominating this Site:	
Partner Contact for this Site (name, phone, email):	

Site Business Name:					
Site Address:					
Site City:		Site State:		Site Zip Code:	

Site Contact Name:	
Site Contact Title:	
Site Contact Phone and Email:	

Site Contact Years at Location:	

How many years has this business been in operation at this location?	
Site Use Type (Community Market, Grocery Store, Gas Station, Quick-service, Dine-in, Hotel, School, etc.)	
What are the business hours per day and days per week?	

1	Does this site acknowledge that participation in the pilot program, and use of stipends to replace systems, is conditional upon providing access site monitoring partners and contractors?		YES ○	NO ○
	a.	Does this site agree to provide such access?	YES ○	NO ○
	b.	Does this site contact agree to complete participation surveys associated with this program?	YES ○	NO ○

2	Does the site have an existing refrigeration contractor that would be the preferred installer of any program related equipment?	YES ◯	NO ◯
	If yes, please share business name, contact name, contact location, phone, email and/or website.		

3	Does the site commit to purchasing and installing equipment that meets the minimum efficiency standards required by the program?	YES ◯	NO ◯

4	Does the site have preferred and reasonable days, dates, and/or times where contractors can remove/replace/install/calibrate a newly installed refrigeration system and associated pre and post data logging equipment?	YES ◯	NO ◯
	If yes, please share details on anticipated or preferred down times.		

5	Does the site have a secondary WICF that may temporarily be used to store refrigerated or frozen foods and beverages during installation, should a secondary space be needed?	YES ◯	NO ◯

6	Has this site been considering replacing or upgrading the WICF system prior to learning about the HECU/HEEU onsite monitoring pilot program?	YES ◯	NO ◯

7	Is the nominated WICF part of new construction, site remodel, or replacing failed equipment? Please explain.

8	Is the nominated WICF currently used as a refrigerator or a freezer?	YES ◯	NO ◯
	If set points are known, please provide.		

9	Is the nominated system being suggested because of concerns about pending system failure?	YES ◯	NO ◯
	Please provide any relevant details if there have been indicators of potential system failure, or there is an urgency for a needed replacement system.		

10	Is the nominated system being suggested because of energy efficiency concerns?	YES ◯	NO ◯
	If yes, please explain.		

11	Does the WICF system have advanced controls?	YES ◯	NO ◯
	If yes, please explain.		

12	Is the nominated WICF system under 10 horsepower?	YES ◯	NO ◯
	What is the estimated horsepower of the system?		

13	What is the manufacturing and installation date of the existing WICF?

14	What is the manufacturing and installation date of the existing condensing unit?

15	Where is the Condensing unit located? (On grade? Roof of WICF? Roof of building?). If on roof of WICF or business building, is permanent roof access available?		
16	Are all parts of the WICF (walls, roof, doors) located indoors and out of the elements?	YES ◯	NO ◯
	If no, explain.		
17	What are the interior dimensions and square footage of the WICF?		
18	Is there more than one WICF refrigerated by this system?	YES ◯	NO ◯
	If yes, explain and provide additional details.		
19	Is there more than one WICF at this site that you would like to nominate for the onsite monitoring pilot? If yes, please provide above information for the separate WICF and system.	YES ◯	NO ◯
	If yes, please summarize other systems and provide separate nomination form.		

Appendix F: On-Site Monitoring Measurement and Verification Plan

Measurement and Verification Draft Plan HECU and HEEU Project

Introduction

This Measurement and Verification (M&V) plan describes in detail how energy and demand savings will be quantified for this project. The M&V plan presented here adheres to the specifications set forth in the International Performance Measurement and Verification Protocol (IPMVP) Core Concepts.

M&V involves the process of using measurements to reliably quantify actual energy savings and/or beneficial load shifting from an energy and demand optimization project within a facility, a process, a building, or a building subsystem. M&V is used to verify that an energy optimization project is achieving its intended objectives. M&V describes how savings are determined from the measurements of energy use before and after implementation of the project intervention, with appropriate adjustments made for changes in conditions. Such adjustments may be routine and expected, while others are non-routine and due to factors unrelated to the project.

This M&V Plan describes how baseline energy use and demand are documented, how they vary, and what factors are its primary drivers. The M&V plan also describes how adjustments to baseline use are made for unexpected events, such as added equipment or loads, or other unforeseen events that materially affect use and savings.

The M&V Plan is required to document and describe the approach to quantifying savings, the key measurements required and computation methods, the timing of these activities, roles and responsibilities of involved parties, and the quality assurance requirements associated with the process.

Project Description

The proposed technology involves modular commercial refrigeration equipment used in walk-in coolers and freezers and remote condensing unit refrigeration cases. The proposed equipment covered in this project involves High-Efficiency Condenser Units ("HECU") and High-Efficiency Evaporator Units ("HEEU"). Savings from these measures stem from a combination of several energy-efficiency components and controls integrated into one refrigeration system. HECUs typically provide savings through the following equipment and controls: high-efficiency compressors, floating head pressure controls, and variable speed condenser fans. HEEUs provide savings through the following equipment and controls: high-efficiency evaporator fan motors, evaporator fan controls that modulate fan speed and operation, and smart defrost controls.

The Focused Pilot will involve measurement and verification to be performed at 10 to 15 yet to be selected sites. The sites are expected to cover a range of customer types, facility sizes, and climate zones to ensure monitoring is representative of key customer types and climate zones for this type of equipment in California.

Measurement and Verification

IPMVP Option and Measurement Boundary

IPMVP Option B (Retrofit Isolation: All Parameter Measurement) will be used for savings determination. Option B was selected because the technology involves the replacement of an existing refrigeration system condenser unit and evaporator unit. Energy use of the equipment affected by the retrofit can easily be separated from the energy use of the rest of the facility.

The parameters to be monitored include condenser unit package power (includes compressor), evaporator unit package power, door openings, evaporator inlet temperature, and ambient air temperature and humidity. Package power is expected to include voltage, amperage, and power factor.

Instrumentations

Baseline and post-installation data will be collected using the equipment in **Table** 30 below. The DENT power logger (or equivalent) will monitor energy consumption through three voltage leads and three current transducers (CTs) (one CT per phase). All data will be collected in one-minute averaged intervals, with exception to door openings which will be collected based on a change of state and duration of each state.

Table 30: Data Collection Variables and Instruments

Variable	Equipment	Accuracy	Frequency
Condenser unit package power	Dent power logger or Equivalent	+/- 1% of full scale	1-minute average
Evaporator unit package power	Dent power logger or Equivalent	+/- 1% of full scale	1-minute average
Evaporator inlet air temperature	Temp. and RH logger	+/-0.63 F and +/-2.5% RH	1-minute average
Refrigerator or freezer door openings	State Logger	±1 minute per month at 25°C	Change of State
Ambient air temperature	Temp. and RH logger	+/-0.63 F and +/-2.5% RH	1-minute average

Ambient temperature data will be collected on-site. As a parallel approach, the implementer will also collect the weather data from the nearest National Oceanic and Atmospheric Administration (NOAA) weather station. The ambient temperature data will be critical for normalizing and calibrating energy patterns to actual meteorological weather observations.

Baseline Period and Conditions

The baseline period will start at least one month before the planned installation of technology. Key conditions during this baseline period that may change in the reporting period are outlined in section 4.2. These conditions, if different in the reporting period from these baseline conditions, may necessitate non-routine adjustments to the baseline energy use.

Reporting Period

The reporting period will start immediately after the installation and commissioning of technology and last at least for a month.

Data Quality

The data will be assessed for gaps and outliers. Outliers are data beyond the expected range of values, e.g., a data point more than two standard deviations away from the average of the relevant data. Outliers will be defined based on sound engineering judgement as well as common statistical practice. Before a data point is eliminated, an explanation for the unexpected data will be sought, and if there is reason to believe that the data are abnormal because of specific mitigating factors, then the data point may be eliminated from the analysis. If a reason for the unexpected data cannot be found, the data will be included in the analysis and will be explained as such.

Data gaps will be filled by the best method available, which may include interpolation or comparison with similar days for all the input data received. Data preparation activities will be fully documented in the savings report.

Handling of Non-Routine Adjustments

Non-routine adjustments are factors that were not expected to change, but that will affect the system's energy use, not as a result of the energy conservation measures installed as part of the retrofit.

Non-Routine Application Process

The M&V effort will require the identification of any non-routine adjustments that need to be quantified. The first step is to ensure that the system's conditions and operations are well documented during the baselining efforts so that the M&V resource can "keep an eye" out for possible changes in building operation or loads during the reporting period.

The next step is to identify any changes in the reporting period from the baseline period. This can be accomplished through interviews with the system owner, periodic site visits, observation of unexpected energy use patterns, or other methods. It is important to bear in mind that not all changes in the system operation need to be (or can reasonably be) accounted for in the M&V effort. Identifying changes that warrant adjustment is a critical part of the process.

The third step in the process is to establish a method to accurately calculate (quantify) how the identified changes will affect the system's energy use. Sometimes these effects can be estimated within the energy modeling that was used to calculate the energy savings for the project. In other cases, side calculation methods must be employed. Applying the appropriate level of rigor and sound engineering principles is key.

Typical Non-Routine Adjustments

Non-routine adjustments that are typically encountered may include:

- A change in the space size (added square feet)
- A change in operating hours or equipment operation (or overrides in operation)
- A change in product type
- Added loads (additional product or infiltration loads)
- A change in temperature setpoints
- A change in production volume

Defining Eligible Non-Routine Adjustments

Table 31 below represents examples of eligible categories, adjustments, triggers, and actions. However, this list is not exhaustive or applicable to all projects.

Table 31: Example Categories

Adjustment	Example Trigger	Action
Structural Changes		
Increased square footage	10% or greater increase.	Submeter new addition. And adjust baseline down based on the increase consumption
Operational Changes		

Adjustment	Example Trigger	Action
Change in operating hours, non-load dependent	Lighting overridden during normally unoccupied hours	kW x additional hours of operation
Change in operating hours, load dependent	RTUs overridden during normally unoccupied hours	kW x additional hours of operation; kW calculated based on loads (weather, etc.) using temperature bin analysis or similar method
Change in production volume	A third production shift added to manufacturing facility	Develop relationship between production volume and energy use. Use relationship to develop regression and calculate energy impact
Change in occupancy schedule	New tenant has longer occupancy schedule in a section of the building	Determine activity type and schedule (Btu/person/hr). Use bin hours and kW x additional hours as needed to calculate impact of additional loads on HVAC system energy use
Change in temperature set points	Tenant wants temperature comfort range changed from 68–74˚F to 70–76˚F	Use bin analysis and engineering principles to determine impact of revised zone temperature setpoints on HVAC system energy use
Change in End Use: Loads		

Adjustment	Example Trigger	Action
Change in use type	Section of building occupancy changed from office space to conference room.	Determine new activity type and schedule (Btu/person/hr). Bin data calculations and standard engineering principles to calculate impact of additional loads on HVAC system energy use Determine if new loads introduced to the space(s); then use bin data calculations and standard engineering principles to calculate impact of additional loads on HVAC system energy use
Addition of end-use equipment	Additional IT equipment added to an office space	Determine additional kW in the space(s). Use bin data calculations and standard engineering principles to calculate impact of additional loads on HVAC system energy use
Change in occupancy density	Phone bank goes in to replace investment firm, adding 22 workers to a suite.	Determine activity type and schedule (Btu/person/hr). Use bin data calculations and standard engineering principles to calculate impact of additional loads on HVAC system energy use

Calculating Non-Routine Adjustments

In general, quantifying the effects of non-routine adjustments on the building's energy use involves use of the original calculation methods used to determine energy savings. For example, if a dynamic building simulation were originally used to calculate energy savings associated with the energy conservation measures (ECMs), this same model could be used to calculate the impact of additional occupancy.

If the original calculations used to estimate energy savings associated with the ECMs are not appropriate to quantifying the effects of the non-routine adjustments, separate calculations will need to be performed to quantify these effects. Calculation methods (regression analysis, temperature bin analysis, etc.) similar to those used to estimate energy savings associated with the ECMs would need to be employed to determine the impact that these non-routine adjustments will have on the building's energy performance.

Once the non-routine adjustment effects have been quantified, these annual, monthly, or hourly values are then applied to the baseline, to "adjust" the delta between the baseline energy use and reporting period energy use, to determine savings.

Acceptance of Proposed Non-routine Adjustments

The M&V agent proposes a non-routine baseline adjustment to the building owner or investor. This should include a reference to this document and the applicable pre-agreed to adjustments (Table 31 above).

M&V Schedule

Table 32: Anticipated Schedule and Timing of Activities for M&V Plan (subject to change)

Tasks	Period
Baseline monitoring equipment installation	By start of June 2023
Baseline monitoring	Immediately after the monitoring equipment installation until the beginning of August.
Technology Installation	Beginning of July 2023
Post-installation monitoring	Immediately after the technology installation and commissioning until the end of September.

Measurement and Verification as Executed

AESC (6 sites)

The monitoring followed the California Monitoring and Evaluation Protocol set by the CPUC. IPMVP Option B (Retrofit Isolation: All Parameter Measurement) was used for savings determination as described in the M&V Plan (above).

Parameters Monitored

The parameters to be monitored include condenser unit package power (includes compressor), evaporator unit package power, door openings, evaporator inlet temperature, and ambient air temperature and humidity. Package power is expected to include voltage, amperage, and power factor.

Instrumentations

Real power in kW was measured using a DENT power logger (or equivalent) with voltage, amperage, and power factor of the three phases as applicable. In cases where enough space was not available to install a DENT power logger with the evaporator unit, voltage and power factor were spot measured, the current was logged using a HOBO data logger and current transformer (CT), and power was calculated using the following formula.

$$Power\ (single\ phase) = Voltage.Current.Power\ Factor$$

WICF temperature and outside air temperature were measured using HOBO temperature and RH logger. WICF door openings were counted using the HOBO state logger. In cases where outside air temperature loggers were missing, nearest weather station data were used.

All parameters except door openings were logged at 1-minute intervals. Door openings were collected as a change of states (Open and Close) and duration of each state.

The accuracies of the loggers used are in Table 33.

Table 33: AESC Data Logger Accuracy

Logger	Make and Model	Parameter	Accuracy
Power Logger	DENT Elite Pro XC	Real power	Better than 1% (<0.2% typical for V, A, kW, PF)
Data Logger and CT	HOBO UX120-006M Split Core AC CT	Current	±2.1% of full scale (includes logger accuracy)
HOBO Temperature and RH Logger	HOBO UX100-011A	Indoor temperature and RH	±0.38°F from 32 to 122°F RH (within 2.5% accuracy)

Logger	Make and Model	Parameter	Accuracy
HOBO Temperature and RH Logger	HOBO MX2301A	External temperature and RH	±0.36 from 32 to 158°F RH ±2.5%
HOBO State Logger	HOBO UX90-001	State (door open)	Maximum state, event, runtime frequency 1 Hz
Clamp Meter	EXTECH 380976	Current, voltage, power factor, TRMS power	Current ±2%+ 20d Voltage ±1%+ 20d True power ±5%+ 20d

Measuring Period

Baseline and Reporting Periods were at least 4 weeks each per site per period.

Non-Routine Adjustments

No non-routine adjustments were required for any site for the typical non-routine adjustments mentioned in the M&V Plan (above).

TRC (4 sites)

The accuracies of the loggers used are in Table 34.

Table 34: TRC Data Logger Accuracy

Attune Cloud Data Logger Measured Point	Make and Model	Parameter	Accuracy
Evaporator Fan, Compressor Unit Power	eGauge Core (EG4015)	Real Power	ANSI C12.20 — 0.5% Compliant
Compressor Unit Intake (Outside Air) T/RH	Dwyer RHP-2R11	Temperature	+/- 0.2°C @25°C (Operating range: -40-60°C)
Compressor Unit Intake (Outside Air) T/RH	Dwyer RHP-2R11	RH	+/- 2% 10-90% RH @25°C (Operating range: 0-100%)
Cooler/Freezer T/RH	Attune T/RH Node (built-in)	Temperature	+/- 0.3°C (Operating range: -40-125°C)
Cooler/Freezer T/RH	Attune T/RH Node (built-in)	RH	+/-2% (Operating range: 0-100%)
Cooler/Freezer Door/Status (Open/Closed)	Attune Node (Contact Closure Bridge)	Open/Closed	N/A

Appendix G: Post-Installation Survey

Post-Installation Survey — Contractors

Thanks for taking a few minutes to share feedback about the high-efficiency refrigeration equipment you recently installed on at

Responses to this "Post installation" survey are an essential part of our program. Your input will help to improve the design of current and future energy programs and incentives in California. Your responses and scoring will be anonymously combined with other participants for program reporting purposes.

How important are each of the following when choosing what refrigeration equipment to recommend to a customer?

	Very important	Somewhat important	Important	Slightly important	Not at all important	Not sure
Initial cost	◯	◯	◯	◯	◯	◯
Ongoing energy costs	◯	◯	◯	◯	◯	◯
Ongoing maintenance costs	◯	◯	◯	◯	◯	◯
Low-Global Warming Potential (GWP) or natural refrigerant	◯	◯	◯	◯	◯	◯
Quiet operation	◯	◯	◯	◯	◯	◯
Reliability	◯	◯	◯	◯	◯	◯
Temperature controls	◯	◯	◯	◯	◯	◯
Ease of use for the customer	◯	◯	◯	◯	◯	◯
Ease of installation	◯	◯	◯	◯	◯	◯
Ongoing energy use	◯	◯	◯	◯	◯	◯
Cooling performance	◯	◯	◯	◯	◯	◯
Equipment availability	◯	◯	◯	◯	◯	◯
Previous experience with similar equipment	◯	◯	◯	◯	◯	◯
Cutting edge technology	◯	◯	◯	◯	◯	◯
Customer satisfaction	◯	◯	◯	◯	◯	◯
	Very important	Somewhat important	Important	Slightly important	Not at all important	Not sure

What else is important to you when choosing refrigeration equipment to install? *Please respond below or leave this blank.*

→

How satisfied are you with the equipment you installed on at in terms of the following aspects...

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	Not sure
Initial cost	○	○	○	○	○	○
Low-Global Warming Potential (GWP) or natural refrigerant	○	○	○	○	○	○
Quiet operation	○	○	○	○	○	○
Reliability	○	○	○	○	○	○
Temperature Controls	○	○	○	○	○	○
Ease of use for the customer	○	○	○	○	○	○
Ease of installation	○	○	○	○	○	○
Ongoing energy use	○	○	○	○	○	○
Cooling performance	○	○	○	○	○	○
Equipment availability	○	○	○	○	○	○
Cutting edge technology	○	○	○	○	○	○
Customer satisfaction	○	○	○	○	○	○
	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	Not sure

← →

When compared to standard-efficiency condensing unit models (lacking variable speed condensing fans, scroll compressors, and floating head pressure controls) and standard-efficiency evaporator models (lacking EC fan motors, variable speed fan controls, defrost controls, and/or electronic expansion valves), how would you score the high efficiency models you installed at Sabrosada across the following aspects?

	Significantly better	Slightly better	Neither better nor worse	Slightly worse	Significantly worse	Not sure
Initial cost	◯	◯	◯	◯	◯	◯
Ongoing energy costs	◯	◯	◯	◯	◯	◯
Ongoing maintenance costs	◯	◯	◯	◯	◯	◯
Low-Global Warming Potential (GWP) or natural refrigerant	◯	◯	◯	◯	◯	◯
Quiet operation	◯	◯	◯	◯	◯	◯
Reliability	◯	◯	◯	◯	◯	◯
Temperature Controls	◯	◯	◯	◯	◯	◯
Ease of use for the customer	◯	◯	◯	◯	◯	◯
Ease of installation	◯	◯	◯	◯	◯	◯
Ongoing energy use	◯	◯	◯	◯	◯	◯
Cooling performance	◯	◯	◯	◯	◯	◯
Equipment availability	◯	◯	◯	◯	◯	◯
	Significantly better	Slightly better	Neither better nor worse	Slightly worse	Significantly worse	Not sure

Did you experience any **supply chain delays** when completing this project? *For example, delays in receiving equipment in a timely manner once purchased or ordered.*

◯ Yes (please describe)

◯ No

◯ Not sure

Did you experience any **delays related to staff availability** when completing this project?

◯ Yes (please describe)

◯ No

◯ Not sure

Did you experience any **other issues or barriers** when completing this project?

- ◯ Yes (please describe)
- ◯ No
- ◯ Not sure

When comparing purchase price for condensing units and evaporators, have you observed a pricing difference between high-efficiency models and standard efficiency models? If so, how would you describe that difference? *Please include a dollar amount.*

Were there other installation costs associated with the high-efficiency equipment (that wouldn't have existed for standard-efficiency equipment)?

- ◯ Yes (please describe)
- ◯ No
- ◯ Not sure

In the last 12 months, what percentage of **new-construction** walk-in refrigeration installations were for standard efficiency condensing unit and/or evaporator models?

0 10 20 30 40 50 60 70 80 90 100

In the last 12 months, what percentage of **replacement** walk-in refrigeration installations were for standard efficiency condensing unit and/or evaporator models?

0 10 20 30 40 50 60 70 80 90 100

Any additional comments?

←

Submit survey

Post-Installation Survey — Customers

Thanks for taking a few minutes to share feedback about the high-efficiency refrigeration equipment you recently installed on . , at .

Responses to this "Post installation" survey are required as part of the stipend distribution process. Additionally, your input will help to improve the design of current and future energy programs and incentives in California. Your responses and scoring will be anonymously combined with other participants for program reporting purposes.

How important are each of the following when choosing refrigeration equipment to install?

	Very important	Somewhat important	Important	Slightly important	Not at all important	Not sure
Initial cost	○	○	○	○	○	○
Ongoing energy costs	○	○	○	○	○	○
Ongoing maintenance costs	○	○	○	○	○	○
Available incentives	○	○	○	○	○	○
Low-Global Warming Potential (GWP) or natural refrigerant	○	○	○	○	○	○
Quiet operation	○	○	○	○	○	○
Reliability	○	○	○	○	○	○
Temperature controls	○	○	○	○	○	○
Ease of use for the customer	○	○	○	○	○	○
Ongoing energy use	○	○	○	○	○	○
Cooling performance	○	○	○	○	○	○
Equipment availability	○	○	○	○	○	○
Previous experience with similar equipment	○	○	○	○	○	○
Cutting edge technology	○	○	○	○	○	○
	Very important	Somewhat important	Important	Slightly important	Not at all important	Not sure

What else is important to you when choosing refrigeration equipment to install? *Please respond below or leave this blank.*

→

How satisfied are you with the equipment you installed on at in terms of the following aspects...

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	Not sure
Initial cost	○	○	○	○	○	○
Available incentives	○	○	○	○	○	○
Low-Global Warming Potential (GWP) or natural refrigerant	○	○	○	○	○	○
Quiet operation	○	○	○	○	○	○
Reliability	○	○	○	○	○	○
Temperature Controls	○	○	○	○	○	○
Ease of use for the customer	○	○	○	○	○	○
Ongoing energy use	○	○	○	○	○	○
Cooling performance	○	○	○	○	○	○
Equipment availability	○	○	○	○	○	○
Cutting edge technology	○	○	○	○	○	○
	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	Not sure

← →

When compared to standard-efficiency condensing unit models (lacking variable speed condensing fans, scroll compressors, and floating head pressure controls) and standard-efficiency evaporator models (lacking EC fan motors, variable speed fan controls, defrost controls, and/or electronic expansion valves), how would you score the high efficiency models you installed at McCoy's Coffee Shop across the following aspects?

	Significantly better	Slightly better	Neither better nor worse	Slightly worse	Significantly worse	Not sure
Initial cost	◯	◯	◯	◯	◯	◯
Ongoing energy costs	◯	◯	◯	◯	◯	◯
Ongoing maintenance costs	◯	◯	◯	◯	◯	◯
Low-Global Warming Potential (GWP) or natural refrigerant	◯	◯	◯	◯	◯	◯
Quiet operation	◯	◯	◯	◯	◯	◯
Reliability	◯	◯	◯	◯	◯	◯
Temperature Controls	◯	◯	◯	◯	◯	◯
Ease of use for the customer	◯	◯	◯	◯	◯	◯
Ongoing energy use	◯	◯	◯	◯	◯	◯
Cooling performance	◯	◯	◯	◯	◯	◯
Equipment availability	◯	◯	◯	◯	◯	◯
	Significantly better	Slightly better	Neither better nor worse	Slightly worse	Significantly worse	Not sure

Did you experience any **supply chain delays** when completing this project? *For example, delays in receiving equipment in a timely manner once purchased or ordered.*

- ◯ Yes (please describe)
- ◯ No
- ◯ Not sure

Did you experience any **delays related to contractor availability** when completing this project?

- ◯ Yes (please describe)
- ◯ No
- ◯ Not sure

Did you experience any **other issues or barriers** when completing this project?

- ◯ Yes (please describe)

[ ]

- ◯ No
- ◯ Not sure

When your refrigeration systems need maintenance, who performs the work?

- ◯ Always done myself or with in-house staff
- ◯ Mostly done myself or with in-house staff
- ◯ Mostly done by contractors
- ◯ Always done by contractors
- ◯ Other (please describe)

[ ]

Since you installed this equipment, have you experienced any issues with it? *For example, refrigerant leaks or malfunctioning controls.*

- ◯ Yes, these issues were:
- ◯ No
- ◯ Not sure

How do your electrical bills after installing this equipment compare to your bills before installing this equipment?

- ◯ Electrical bills have gone up
- ◯ Electrical bills have stayed about the same
- ◯ Electrical bills have gone down
- ◯ Not sure

Are there other walk-in cooler refrigeration systems at your business that are **not** high-efficiency? If so, approximately how many?

(As a reminder standard-efficiency condensing units are defined as having variable speed condensing fans, scroll compressors, and floating head pressure controls and standard-efficiency evaporator units are defined as having EC fan motors, variable speed fan controls, defrost controls, and/or electronic expansion valves.)

- ◯ Yes, approximately (*please enter a number*):

  [ ]

- ◯ No
- ◯ Not sure

Any additional comments?

[ ]

← Submit survey

Appendix H: Midstream Incentive Pilot Program Marketing Collateral

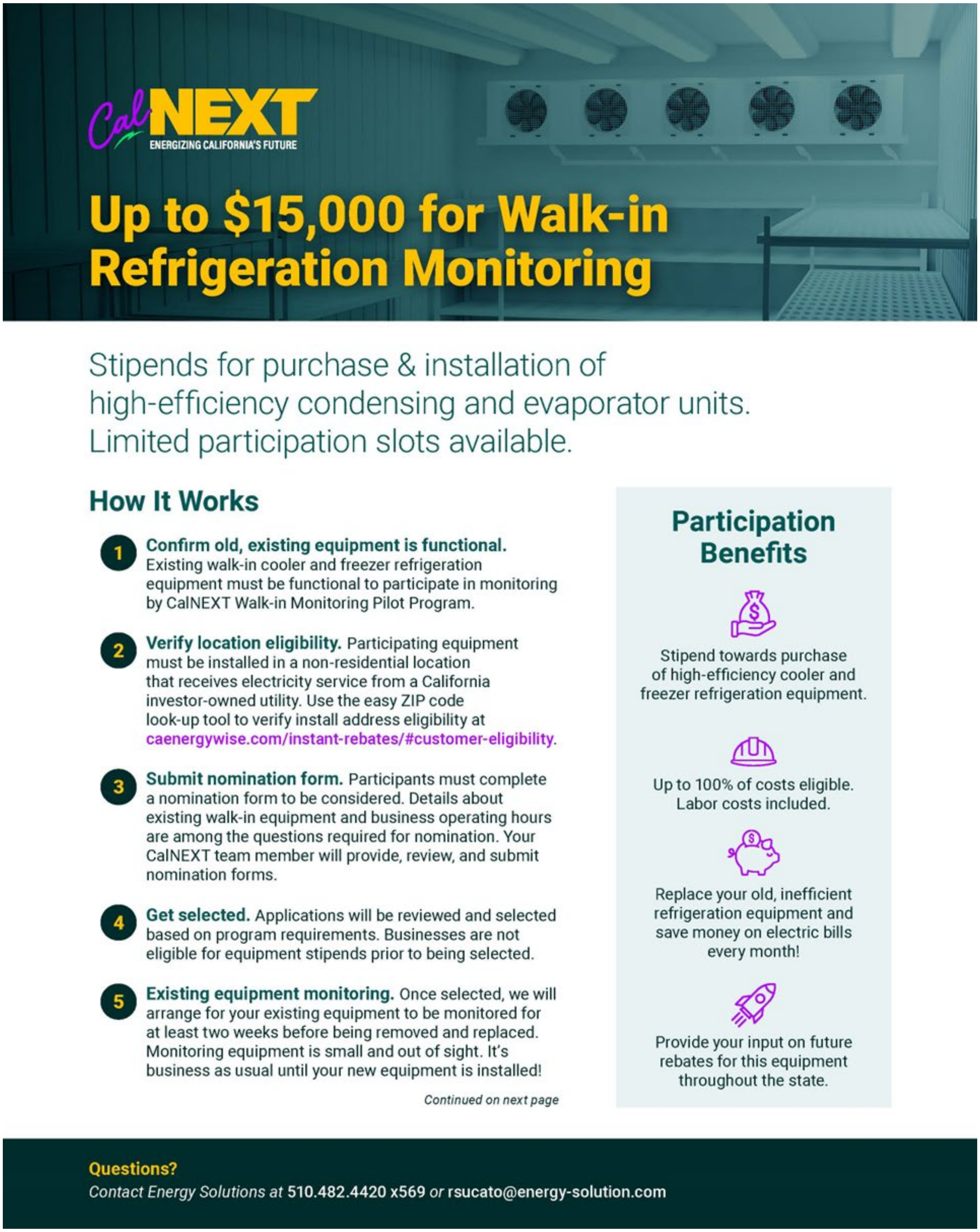


Figure 15: Distributor midstream incentive flyer — front

Walk-in Rebates Pilot Program

Eligibility

Invited distributors who sell qualifying high-efficiency equipment to commercial facilities in the California investor-owned utilities electric service territory are eligible to participate.

Pilot Duration

This is a short-term pilot—scheduled to operate for six months, from March 15, 2023 through September 30, 2023. The purpose of the pilot is to test program features to identify the best ways to promote the sale and stocking of this high-efficiency equipment to increase its use in California.

High-Efficiency Condensing Units for Refrigeration

Eligible condensing units must have:

- ☑ Floating head pressure controls
- ☑ Modulating speed condenser fans
- ☑ Scroll compressor or variable speed reciprocating compressor

High-Efficiency Evaporator Units for Refrigeration

Eligible evaporator units must have:

- ☑ EC motors, Integrated motor controls
- ☑ Optional: Electronic Expansion Valve (EEV), Integrated controls to optimize defrost

Rebate Amounts

High-Efficiency Condensing Units

$400 – $1,200*
per unit

High-Efficiency Evaporator Units

$150 – $1,500†
per unit

* Rebate amount depends on unit horsepower and are still being finalized

† Rebate amount depends on number of fans and are still being finalized

The CalNEXT program is designed and implemented by Cohen Ventures, Inc., DBA Energy Solutions ("Energy Solutions"). Southern California Edison Company, on behalf of itself, Pacific Gas and Electric Company, and San Diego Gas & Electric® Company (collectively, the "CA Electric IOUs"), has contracted with Energy Solutions for CalNEXT. CalNEXT is available in each of the CA Electric IOU's service territories. Customers who participate in CalNEXT are under individual agreements between the customer and Energy Solutions or Energy Solutions' subcontractors (Terms of Use). The CA Electric IOUs are not parties to, nor guarantors of, any Terms of Use with Energy Solutions. The CA Electric IOUs have no contractual obligation, directly or indirectly, to the customer. The CA Electric IOUs are not liable for any actions or inactions of Energy Solutions, or any distributor, vendor, installer, or manufacturer of product(s) offered through CalNEXT. The CA Electric IOUs do not recommend, endorse, qualify, guarantee, or make any representations or warranties (express or implied) regarding the findings, services, work, quality, financial stability, or performance of Energy Solutions or any of Energy Solutions' distributors, contractors, subcontractors, installers of products, or any product brand listed on Energy Solutions' website or provided, directly or indirectly, by Energy Solutions. If applicable, prior to entering into any Terms of Use, customers should thoroughly review the terms and conditions of such Terms of Use so they are fully informed of their rights and obligations under the Terms of Use, and should perform their own research and due diligence, and obtain multiple bids or quotes when seeking a contractor to perform work of any type.

Figure 16: Distributor midstream incentive flyer — back

Appendix I: Distributor Interview Questions

1) **Stocking practices and sales specific to participating models from the pilot**
   a) Did you sell the models that were rebated in the pilot prior to the pilot?
      i) If so, can you share how many units of these same models were sold during this same period last year? Or ever?
         (1) Were sales of QPL models during the pilot greater than sales prior to the pilot?
   b) Were these models kept in stock during the pilot? Or did you order them from the manufacturer at the time of sale to customer/contractor?
   c) Prior to the pilot, did you maintain stock of any of the QPL models?
   d) Prior to the pilot, did you order any of the QPL models directly for your customers?
   e) Will you continue to stock or recommend these models after the pilot has ended?
      i) If no, would you stock these models if the pilot incentives were to become a permanent program?
   f) During the pilot period, what percentage of your walk-in cooler and freezer evaporator sales (not parts repair) were HEEUs.
   g) How many Walk-in cooler and freezer evaporators do you typically sell in a calendar year?
      i) How many in 2023?
   h) How many walk-in cooler and freezer condensing units do you typically sell in a calendar year?
      i) How many in 2023?

2) **Contractor and customer knowledge and education**
   a) For the sales of high-efficiency units you sold and received rebates for as part of this pilot:
      i) What percentage of the sales did your sales team recommend the model that was chosen?
      ii) What percentage of the sales was the specific model requested by the contractor?
      iii) What percentage of the sales was the specific model requested by the customer?
   b) Were contractors hesitant to suggest more expensive, high EE models to their customers?
   c) Are you aware of contractors requesting payback analysis, or sharing payback analysis with end-use customers?
   d) What kind of pushback, if any, do you receive from contractors about HE equipment sales?
   e) Are you aware of any sales employees who felt the EE equipment had downsides that were overlooked by the pilot program?
      i) If so, what are they?

3) **Spiffs**
   a) Do you feel the spiffs were a motivating factor for signing up for the pilot?
   b) What did you do with spiffs? (Pass straight to sales rep? Add to general sales fund? Used for internal gifts/awards? Used to offset increased/new HECU/HEEU stocking? Other?)
   c) If the spiff isn't shared with the sales rep, do you feel the spiffs are adequate to offset administrative costs associated with completing claims in Iris?

4) **HEEU Incentives**
   a) Did you feel the evaporator unit incentives were adequate to help customers overcome first-cost barriers?
   b) Do you feel that collection of incentives, spiffs, and potentially increased sales and/or margins offset the administrative costs of participating in the pilot program?
      i) Do you feel your answer would change if you knew the pilot program was permanent ("would last 2 years or more")?
   c) Any suggestions on alternative incentive structures?
      i) Per unit pricing vs. per fan?
      ii) Adding or removing tiers?
      iii) Higher or lower allocation to Tier 1 vs. Tier 2?

    iv) Incentive values specific to medium temperature applications vs. low-temperature applications (fridge vs. freezer)?
  d) Do you believe the HEEU QPL thoroughly encompassed known models from their suppliers or the marketplace?
    i) If "no," can you share specific manufacturers and models you know are overlooked?

5) **HECUs - zero participation - reasons and suggested changes**
  Point to clarify: The distributor did not have any Condenser unit claims or incentive submissions during the pilot period.
  a) Were you surprised that no HECUs were sold during the pilot period?
  b) Had you sold qualifying HECUs prior to participating in the pilot?
  c) Did you stock HECUs locally during the pilot period?
  d) Did you stock HECUs locally prior to the pilot period?
  e) Do you believe the sales reps advocated for HECU's with an equal enthusiasm and effort as the HEEUs?
  f) Are you aware of any supply chain issues that affected HECU participation during the pilot period?
  g) Are annual standard efficiency condensing unit sales (by unit) typically less than annual evaporator unit sales?
    i) Please answer specifically to Walk-in coolers and freezers, as well as other relevant HVAC applications.
    ii) In a typical calendar year, what is the ratio of condensing unit sales to evaporator sales?
  h) Do you believe that HECU incentives were adequate to drive high-efficiency sales vs. standard efficiency condensing unit sales?
  i) Do you believe that the spiffs were adequate to drive HECU sales vs. standard efficiency condensing units?
  j) Do you believe that condensing unit part repairability limited complete-unit HECU sales/participation?
    i) What about new construction?
      (1) Do you have an opinion on why there was no HECU participation?
  k) Do you believe the HECU QPL thoroughly encompassed known models from your suppliers or the marketplace?
    i) If "no," can you share specific manufacturers and models you know are overlooked?

6) **Distributor take-aways and other questions:**
  a) Package refrigeration systems
    i) Are you aware of package refrigeration systems for walk-in coolers and freezers? If so, do you have any opinions on them you would like to share? (Pros, cons, low-GWP refrigerant, etc.)
    ii) Do you have a manufacturer that supplies package refrigeration systems?
      (1) If yes, what manufacturer and models?
    iii) Have you sold a package refrigeration system for a walk-in cooler or freezer in 2024?
      (1) In 2023?
    iv) Do you stock package refrigeration systems?
    v) Are you aware of contractors and/or customers requesting package refrigeration systems?
    vi) Do you believe that a similar incentive and spiff program for package refrigeration systems would help to increase market adoption?
  b) If the pilot were not ending, would you continue to participate with the program "as-is"?
    i) If "no," what changes would be needed to participate?
  c) If the pilot were not ending, would you put a larger effort into increasing stocking practices, sales team training, internal or external marketing, or any other efforts that indicate embracing the pilot program's permanence?
  d) Do you believe that a continued incentive (and spiff) program would accelerate HECU/HEEU sales and increase market adoption?

e) Do you have a preference regarding incentive-pass-through mandates? If so, what would it be?
   i) Do you believe that either pass-through design would reduce customer sales and market adoption?
f) Do you feel like incentive reimbursement and spiffs were received in a timely manner?
   i) During the pilot, the average time between correct claim submittal and incentive check delivery to distributor was approximately two weeks. Would you be less likely to participate in future incentive programs if payment was longer?
      (1) 4 weeks?
      (2) 6 weeks?
      (3) 8 weeks?
g) Are you a current participant in other incentives programs?
   i) If yes, what is the other incentive program?
      (1) What equipment is incentivized?
      (2) How do you request reimbursement of incentives?
      (3) How long does it take to receive reimbursement in those other programs?
      (4) Does that program require full incentive pass-through and invoice documentation of incentives?
h) Do you believe a permanent program would have more sales and momentum than the pilot program, knowing the program is not for a limited time?
i) Did you limit participation to individual stores or regions?
   i) If "yes," would you continue to selectively participate if the pilot were a permanent program?
j) Would you want the midstream incentive pilot program to become permanent?
k) Do you have any additional feedback about the pilot program or input for consideration in future, permanent program designs?

Appendix J: Site Monitoring Summary Data

Summary figures from site monitoring baseline, retrofit, baseline vs. retrofit differences, and yearly energy are shown below in Figure 17–20. A spreadsheet containing the Site Monitoring regression and normalization analysis can be found in the attached *Appendix J: Site Monitoring Summary Data.xlsx file*

						Baseline							
									Condensers		Evap	Total	Yearly
Site ID	Location	System Temp	Retrofit Condenser HP	Retrofit Evaporator Fan Count	Climate Zone	Baseline Norm. Method	Baseline Avg. Indoor Temp	Baseline Avg. Indoor Temp (Kelvin)	Baseline Meas. Condenser Power [W]	Baseline Norm. Condenser Power [W]	Baseline Evap. Power [W]	Baseline Total Power [W]	Baseline Yearly Energy [kWh]
Site 01	Oakland, CA	Medium	2	2	3	MLR	38	276.45	653	553	130	683	5,987
Site 02	Stanton, CA	Medium	1.5	2	8	LR	36	275.58	798	691	251	942	8,249
Site 03	Rancho Santa Margarita, CA	Low	3	2	8	MLR	0	255.37	1,457	1,428	313	1,741	15,250
Site 04	Huntington Beach, CA	Medium	0.9	2	6	MLR	37	276.13	928	784	175	958	8,396
Site 05	Brisbane, CA	Medium	2.5	2	3	LR2	38	276.58	644	588	290	878	7,688
Site 06	San Francisco, CA	Medium	5	3	3	LR1	43	279.02	2,027	1,364	255	1,619	14,182
Site 07	Clovis, CA	Medium	0.7	1	13	MLR	39	277.20	878	1,091	180	1,271	11,130
Site 08	Selma, CA	Medium	1	2	13	LR1	39	277.32	876	847	404	1,251	10,955
Site 09	Selma, CA	Low	2	2	13	LR	7	259.10	1,481	1,531	169	1,700	14,891
Site 10	Fresno, CA	Medium	1	2	13	LR1	46	280.76	1,149	857	155	1,012	8,863
Site Totals	**All Sites**	**All**							**10,893**	**9,733**	**2,321**	**12,054**	**105,591**
Site Average - All	*All Sites*	*All*					*32*	*273*	*1,089*	*973*	*232*	*1,205*	*10,559*
Site Average - Medium Temp	*Medium Temp*	*Medium*					*40*	*277*	*994*	*847*	*230*	*1,077*	*9,431*
Site Average - Low Temp	*Low Temp*	*Low*					*3*	*257*	*1,469*	*1,479*	*241*	*1,720*	*15,070*

Figure 17: Site monitoring baseline equipment summary

						Retrofit						
								Condensers		Evap	Total	Yearly
Site ID	Location	System Temp	Retrofit Condenser HP	Retrofit Evaporator Fan Count	Climate Zone	Retrofit Norm. Method	Retrofit Avg. Indoor Temp	Retrofit Meas. Condenser Power [W]	Retrofit Norm. Condenser Power [W]	Retrofit Evap. Power [W]	Retrofit Total Power [W]	Retrofit Yearly Energy [kWh]
Site 01	Oakland, CA	Medium	2	2	3	MLR	36	404	421	130	551	4,828
Site 02	Stanton, CA	Medium	1.5	2	8	MLR	38	287	321	76	398	3,486
Site 03	Rancho Santa Margarita, CA	Low	3	2	8	LR	(5)	839	620	359	979	8,578
Site 04	Huntington Beach, CA	Medium	0.9	2	6	LR	33	416	472	113	585	5,124
Site 05	Brisbane, CA	Medium	2.5	2	3	MLR	38	267	237	53	290	2,541
Site 06	San Francisco, CA	Medium	5	3	3	MLR	43	1,221	539	139	678	5,935
Site 07	Clovis, CA	Medium	0.7	1	13	LR	35	216	241	32	273	2,389
Site 08	Selma, CA	Medium	1	2	13	MLR	44	799	814	171	985	8,626
Site 09	Selma, CA	Low	2	2	13	LR	9	1,042	833	153	986	8,638
Site 10	Fresno, CA	Medium	1	2	13	MLR	36	424	503	64	567	4,964
Site Totals	**All Sites**	**All**						**5,914**	**5,000**	**1,291**	**6,291**	**55,110**
Site Average - All	*All Sites*	*All*					*31*	*591*	*500*	*129*	*629*	*5,511*
Site Average - Medium Temp	*Medium Temp*	*Medium*					*38*	*504*	*443*	*97*	*541*	*4,737*
Site Average - Low Temp	*Low Temp*	*Low*					*2*	*940*	*727*	*256*	*983*	*8,608*

Figure 18: Site monitoring retrofit equipment summary

						% Diff						Diff						
							Condensers		Evap	Total	Yearly		Condensers			Evap	Total	Yearly
Site ID	Location	System Temp	Retrofit Condenser HP	Retrofit Evaporator Fan Count	Climate Zone	% Diff Avg. Indoor Temp (Kelvin)	% Diff Meas. Condenser Power [W]	% Diff Norm. Condenser Power [W]	% Diff Evap. Power [W]	% Diff Total Power [W]	% Diff Yearly Energy [kWh]	Diff Avg. Indoor Temp (F)	Diff Meas. Condenser Power [W]	Diff Norm. Condenser Power [W]	Diff Meas. vs Norm. Condenser Power [W]	Diff Evap. Power [W]	Diff Total Power [W]	Diff Yearly Energy [kWh]
Site 01	Oakland, CA	Medium	2	2	3	-0.292%	-38%	-24%	0%	-19%	-19%	(1.46)	(249.56)	(132.00)	117.56	(0.29)	(132.29)	(1,159)
Site 02	Stanton, CA	Medium	1.5	2	8	0.260%	-64%	-53%	-70%	-58%	-58%	1.29	(511.17)	(369.42)	141.75	(174.39)	(543.81)	(4,764)
Site 03	Rancho Santa Margarita, CA	Low	3	2	8	-1.034%	-42%	-57%	15%	-44%	-44%	(4.75)	(618.39)	(807.30)	(188.91)	45.58	(761.72)	(6,673)
Site 04	Huntington Beach, CA	Medium	0.9	2	6	-0.922%	-55%	-40%	-35%	-39%	-39%	(4.58)	(511.67)	(311.95)	199.72	(61.55)	(373.50)	(3,272)
Site 05	Brisbane, CA	Medium	2.5	2	3	0.000%	-59%	-60%	-82%	-67%	-67%	0.00	(377.52)	(350.97)	26.55	(236.61)	(587.58)	(5,147)
Site 06	San Francisco, CA	Medium	5	3	3	0.178%	-40%	-61%	-46%	-58%	-58%	0.89	(806.47)	(825.55)	(19.08)	(115.89)	(941.44)	(8,247)
Site 07	Clovis, CA	Medium	0.7	1	13	-0.913%	-75%	-78%	-82%	-79%	-79%	(4.56)	(662.03)	(850.06)	(188.03)	(147.80)	(997.86)	(8,741)
Site 08	Selma, CA	Medium	1	2	13	0.849%	-9%	-4%	-58%	-21%	-21%	4.24	(77.07)	(33.33)	43.74	(232.43)	(265.76)	(2,328)
Site 09	Selma, CA	Low	2	2	13	0.406%	-30%	-46%	-9%	-42%	-42%	1.89	(439.97)	(698.37)	(258.40)	(15.36)	(713.74)	(6,252)
Site 10	Fresno, CA	Medium	1	2	13	-1.939%	-63%	-41%	-59%	-44%	-44%	(9.80)	(725.58)	(353.57)	372.01	(91.47)	(445.04)	(3,899)
Site Totals	**All Sites**	**All**											**(4,979.44)**	**(4,732.53)**	**246.91**	**(1,030.22)**	**(5,762.75)**	**(50,482)**
Site Average - All	*All Sites*	*All*				*-0.341%*	*-48%*	*-46%*	*-43%*	*-47%*	*-47%*	*(1.68)*	*(497.94)*	*(473.25)*	*24.69*	*(103.02)*	*(576.27)*	*(5,048)*
Site Average - Medium Temp	*Medium Temp*	*Medium*				*-0.348%*	*-50%*	*-45%*	*-54%*	*-48%*	*-48%*	*(1.75)*	*(490.13)*	*(403.36)*	*86.78*	*(132.55)*	*(535.91)*	*(4,695)*
Site Average - Low Temp	*Low Temp*	*Low*				*-0.314%*	*-36%*	*-51%*	*3%*	*-43%*	*-43%*	*(1.43)*	*(529.18)*	*(752.84)*	*(223.66)*	*15.11*	*(737.73)*	*(6,463)*

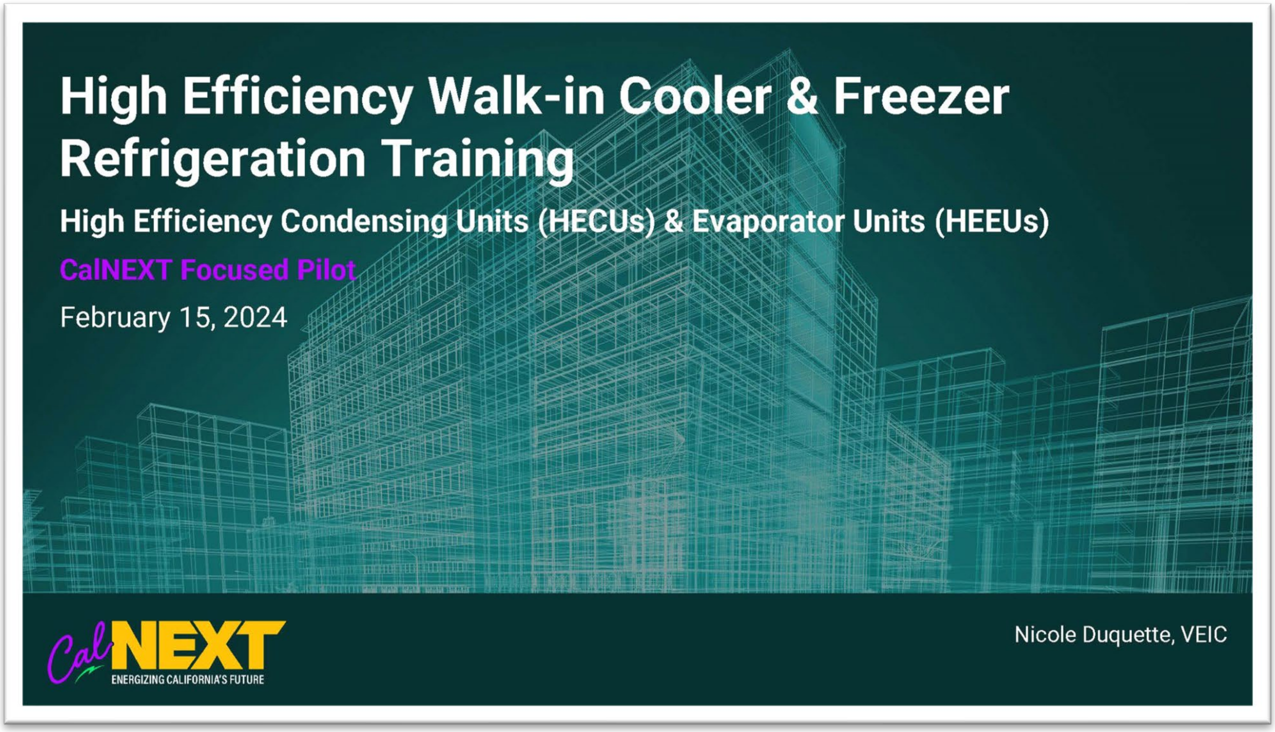
Figure 19: Site monitoring baseline vs. retrofit equipment summary (unit and percentage)

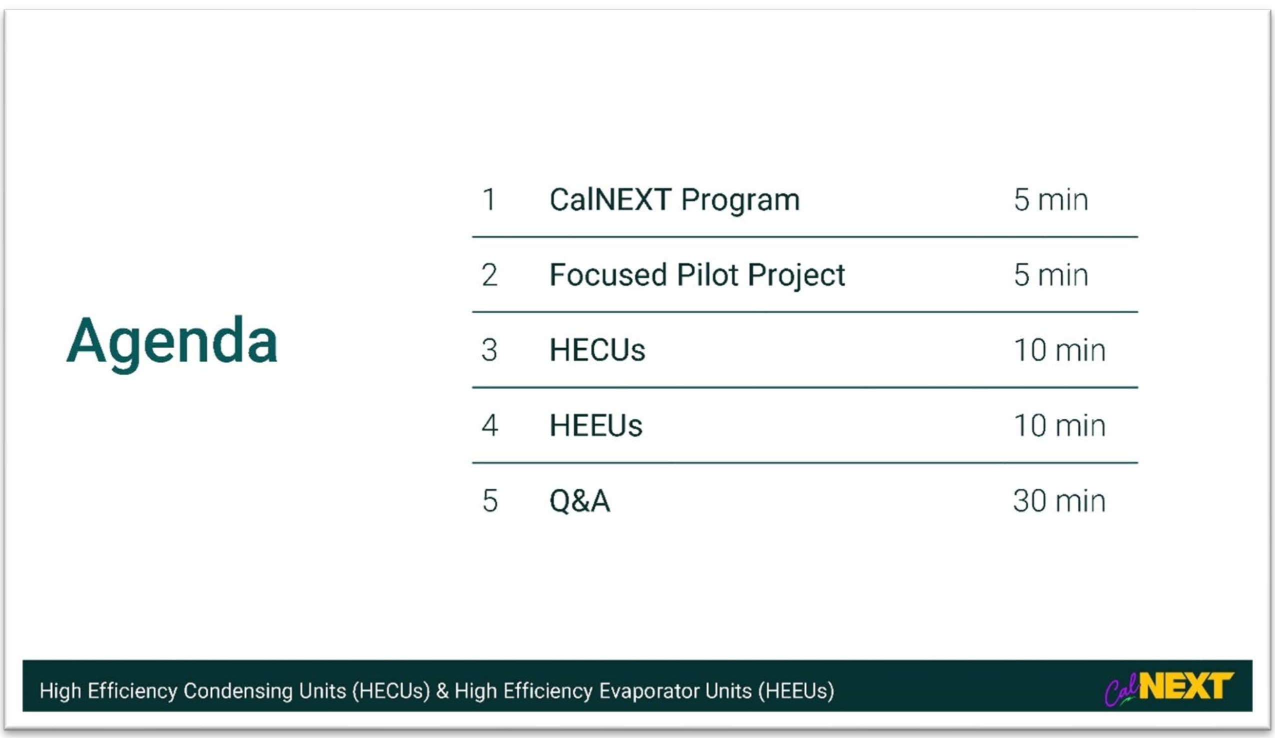
						Yearly Baseline			Yearly Retrofit			Yearly Diff		
						Condenser	Evap	Total	Condenser	Evap	Total	Condenser	Evap	Total
Site ID	**Location**	**System Temp**	**Retrofit Condenser HP**	**Retrofit Evaporator Fan Count**	**Climate Zone**	**Baseline Norm. Condenser Yearly Energy [kWh]**	**Baseline Evap Yearly Energy [kWh]**	**Baseline Yearly Energy [kWh] (2)**	**Retrofit Norm. Condenser Yearly Energy [kWh]**	**Retrofit Evap. Yearly Energy [kWh]**	**Retrofit Yearly Energy [kWh] (2)**	**Diff Norm. Condenser Yearly Energy [kWh]**	**Diff Evap. Yearly Energy [kWh]**	**Diff Yearly Energy [kWh] (2)**
Site 01	Oakland, CA	Medium	2	2	3	4,848	1,139	5,987	3,691	1,137	4,828	(1,156)	(3)	(1,159)
Site 02	Stanton, CA	Medium	1.5	2	8	6,052	2,197	8,249	2,816	669	3,486	(3,236)	(1,528)	(4,764)
Site 03	Rancho Santa Margarita, CA	Low	3	2	8	12,505	2,745	15,250	5,433	3,144	8,578	(7,072)	399	(6,673)
Site 04	Huntington Beach, CA	Medium	0.9	2	6	6,865	1,531	8,396	4,133	992	5,124	(2,733)	(539)	(3,272)
Site 05	Brisbane, CA	Medium	2.5	2	3	5,147	2,541	7,688	2,072	469	2,541	(3,075)	(2,073)	(5,147)
Site 06	San Francisco, CA	Medium	5	3	3	11,953	2,230	14,182	4,721	1,215	5,935	(7,232)	(1,015)	(8,247)
Site 07	Clovis, CA	Medium	0.7	1	13	9,553	1,577	11,130	2,107	282	2,389	(7,447)	(1,295)	(8,741)
Site 08	Selma, CA	Medium	1	2	13	7,420	3,535	10,955	7,128	1,499	8,626	(292)	(2,036)	(2,328)
Site 09	Selma, CA	Low	2	2	13	13,413	1,478	14,891	7,295	1,343	8,638	(6,118)	(135)	(6,252)
Site 10	Fresno, CA	Medium	1	2	13	7,505	1,358	8,863	4,408	557	4,964	(3,097)	(801)	(3,899)
Site Totals	**All Sites**	**All**				**85,261**	**20,330**	**105,591**	**43,804**	**11,306**	**55,110**	**(41,457)**	**(9,025)**	**(50,482)**
Site Average - All	*All Sites*	*All*				*8,526*	*2,033*	*10,559*	*4,380*	*1,131*	*5,511*	*(4,146)*	*(902)*	*(5,048)*
Site Average - Medium Temp	*Medium Temp*	*Medium*				*7,418*	*2,013*	*9,431*	*3,884*	*852*	*4,737*	*(3,533)*	*(1,161)*	*(4,695)*
Site Average - Low Temp	*Low Temp*	*Low*				*12,959*	*2,111*	*15,070*	*6,364*	*2,244*	*8,608*	*(6,595)*	*132*	*(6,463)*

Figure 20: Site monitoring equipment yearly energy summary

Appendix K: Contractor Training Webinar

A presentation containing the Contractor Training Webinar slides can be found below.






CalNEXT Program
CalNEXT's vision is to identify emerging technology trends and bring commercially available technologies to the energy efficiency program portfolio.
Appliances & Plug Loads
HVAC
Lighting
Process Loads
Water Heating
Whole Buildings
High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)
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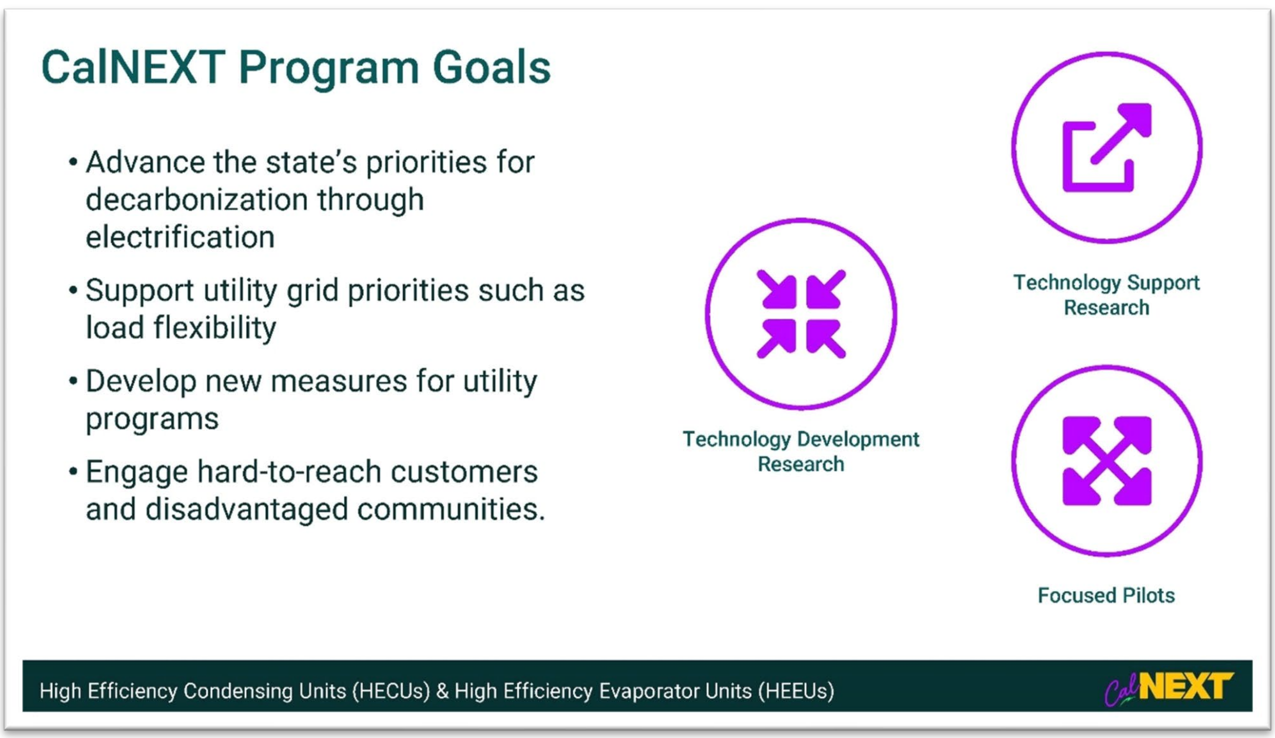
CalNEXT Program Goals
• Advance the state's priorities for decarbonization through electrification
• Support utility grid priorities such as load flexibility
• Develop new measures for utility programs
• Engage hard-to-reach customers and disadvantaged communities.
Technology Support Research
Technology Development Research
Focused Pilots
High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)
CalNEXT

CalNEXT HECU & HEEU Focused Pilot Project

High Efficiency Condensing Units (HECU)

High Efficiency Evaporator Units (HEEU)

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

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CalNEXT HECU & HEEU Focused Pilot Project

Market Characterization

- Evaluate energy efficiency and decarbonization benefits
- Identify opportunities, barriers, and market potential
- Define supply chain channels and key market actors

Midstream Incentive Pilot

- Limited time incentive program for HECU and HEEU equipment
- Incentives available through participating distributors
- Program open while funding available or until end of May
- Equipment must be in eligible customer zip code

Equipment Performance

- Development of a qualified products list (QPL)
- Onsite equipment monitoring
- Equipment energy performance simulation modeling

Utility Support

- Recommendations for new energy efficiency measures
- Workforce development, education and trainings
- Standardized measure development (eTRM)

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

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Contractor & Distributor Benefits & Barriers

Benefits

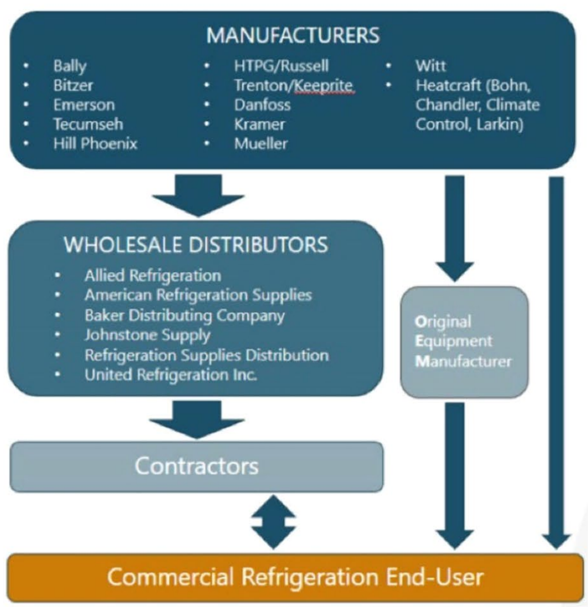
- Large market potential and high measure volume
- Higher profit margins from sales of high efficiency equipment
- Encourage full system retrofit over equipment replacement
- Shifts the service model from reactive maintenance calls to a preventative maintenance
- Builds customer trust and retention

Barriers

- First cost
- Inventory and stocking practices
- Equipment lead times

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

Supply Chain Channels & Key Market Actors



High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

EE Program Impact Potential

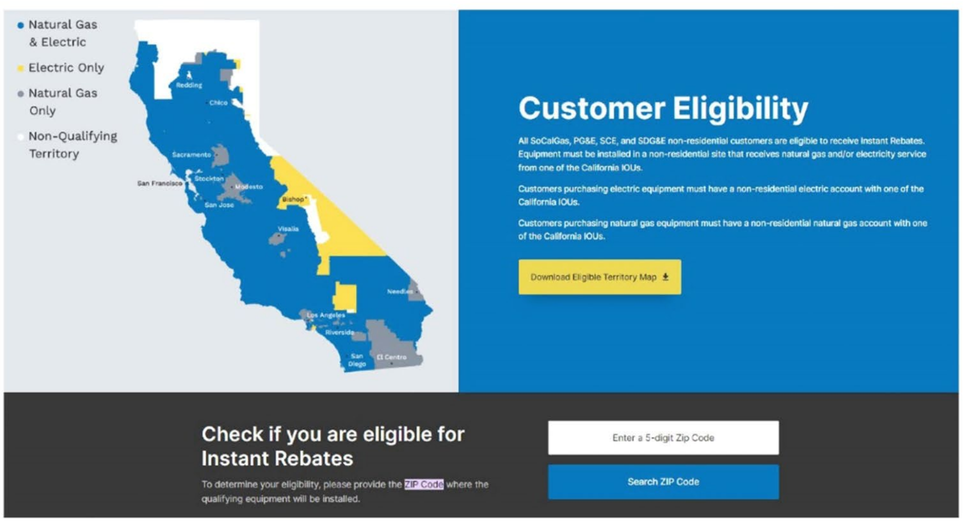
Based on data collected from interviews with key market actors and national efficiency programs

EQUIPMENT	CALIFORNIA HIGH EFFICIENCY MEASURE MARKET POTENTIAL	PROGRAM POTENTIAL INCENTIVES	PROGRAM POTENTIAL ENERGY SAVINGS
High-Efficiency Condensing Units	750 units/year 5% penetration of 210,000 units	$1,132,000	**1,500 MWh**
High-Efficiency Evaporator Units	3,470 units/year 10% penetration of 750,000 units	$2,605,000	**20,000 MWh**

Source: CalNEXT Market Characterization Study

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

Midstream Incentive Pilot - Customer Zip Code Eligibility



https://caenergywise.com/instant-rebates

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

Midstream Incentive Pilot - Participating Distributors

American Refrigeration Supplies

Northern California - 6 locations - Southern California - 4 locations

Allied Refrigeration

16 locations - SF Bay area, Central and Southern California

Refrigeration Supplies Distributor

43 Locations - California Statewide

United Refrigeration

27 locations – Sacramento, SF Bay area, Central and Southern California

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

Qualified Products List (QPL)

Manufacturer	# Qualified Products	Product Size (hp)
Bally	58	0.8 - 6
Bitzer	8	3 - 5
Copeland	2	3 - 6
Danfoss	14	2 - 5
Emerson	67	1 - 6
Heatcraft Refrigeration Products	1401	1 - 6
KeepRite	48	0.75 - 6
Kramer	42	1 - 6
Mueller	9	3.5 - 5
RSG	388	1 - 10
Russell	42	1 - 6
Tecumseh	48	2 - 6
Trenton	244	0.7 - 10
Witt	42	1 - 6

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

HECU – Benefits & Components

- Customer Benefits
  - Increased energy efficiency
  - Reduced maintenance
  - Improved equipment reliability
- High-Efficiency Components
  - Variable speed condenser fans
  - Scroll compressor
  - Floating head pressure controls
- Incentive Structure
  - 3 HP or small compressor rating – Up to $400/HP
  - >3 to 10HP compressor rating – Up to $200/HP

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs) CalNEXT

HECU – Customer Economics

- 0.5-6 hp units make up 70% of the market
- Cost 10-20% more than standard efficiency units
- Incentives estimated at 60-80% incremental cost

TEMPERATURE RATING	AVERAGE ENERGY SAVINGS PER UNIT	AVERAGE COST SAVINGS PER UNIT ($0.30/KWH)	AVERAGE INCREMENTAL COST	AVERAGE PAYBACK W/ INCENTIVES
Medium Temp	3,500 kWh/year	$1,050	$600 - $1,300 per HP	<2 years
Low Temp	2,750 kWh/year	$825		

Source: CalNEXT Market Characterization Study

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs) CalNEXT

HEEU – Benefits & Components

- Customer Benefits
  - Increased energy efficiency
  - Reduced maintenance
  - Improved equipment reliability
- High Efficiency Components
  - Variable speed evaporator fans
  - Evaporator fan motors controls
  - Defrost controls
  - Electronic Expansion Valve

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

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HEEU – Incentive Structure

- Incentive Program Tiers
  - **Tier 1**
    - EC fan motors
    - Variable speed fan controls
  - **Tier 2**
    - EC fan motors
    - Variable speed fan controls
    - Defrost controls
    - Electronic expansion valve
- Incentive Structure
  - Tier 1 Rebate – Up to $150/fan
  - Tier 2 Rebate – Up to $250/ fan

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

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HEEU – Customer Economics

- Average size 1-6 fans
- Cost 8-15% more than standard efficiency units
- Incentives estimated at 60-80% incremental cost

UNIT	AVERAGE ENERGY SAVINGS PER UNIT	AVERAGE COST SAVINGS PER UNIT ($0.30/KWH)	AVERAGE INCREMENTAL COST	AVERAGE PAYBACK W/ INCENTIVES
Evaporator	1,900 kWh/year	$570	$300-$600 per fan	<2 years

Source: CalNEXT Market Characterization Study

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

Questions to Consider

- What equipment do you install with your customers?
- Are customers interested in efficiency?
- What barriers do you face in recommending or installing high efficiency equipment – first cost, inventory, lead times, technical knowledge?
- What additional training topics would like you like to see offered on commercial refrigeration?
- Are refrigerants part of the conversation with customers?

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

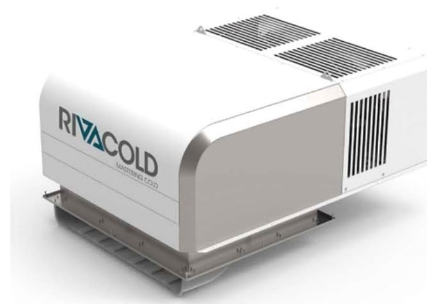
Natural Refrigerant Equipment

CO2 (R-744) Products

- Up to ~5 hp
- Manufacturers
  - Rivacold
  - Hillphoenix
  - M&M Carnot
  - Zero Zone
  - Area Cooling Solutions

Propane (R-290) Products

- Up to ~2 hp
- Manufacturers
  - Rivacold
  - Hussmann
  - Danfoss/Zanotti/AHT
  - Copeland
  - Tecumseh



High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

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Resources & Links

- CalNEXT Website

CalNEXT Program Partners

- Energy Solutions
- VEIC

Emerging Technology Programs & Collaboratives

- Gas Emerging Technologies (GET)
- Demand Response Emerging Technologies (DRET)
- California Emerging Technologies Program (CA-ETP)
- Emerging Technologies Coordinating Council (ETCC-CA)

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Energy Solutions

veic

High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)

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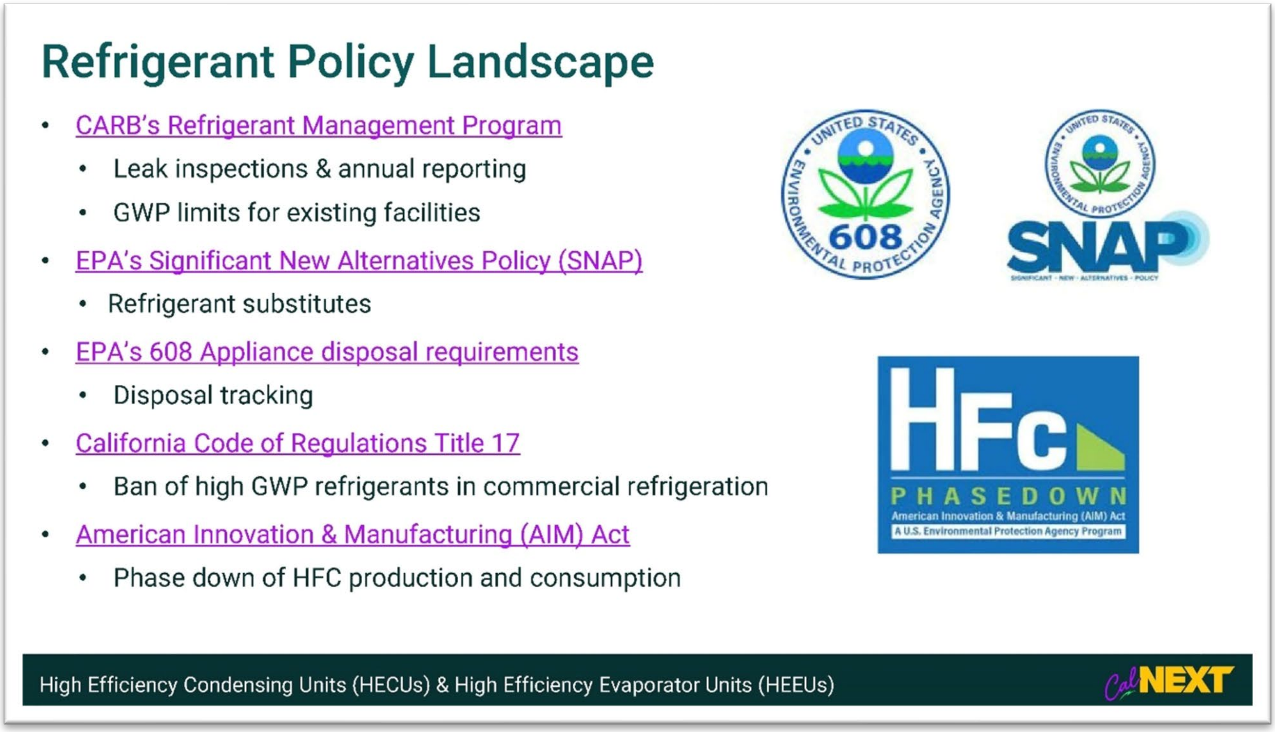
Refrigerant Policy Landscape
CARB's Refrigerant Management Program
Leak inspections & annual reporting
GWP limits for existing facilities
EPA's Significant New Alternatives Policy (SNAP)
Refrigerant substitutes
EPA's 608 Appliance disposal requirements
Disposal tracking
California Code of Regulations Title 17
Ban of high GWP refrigerants in commercial refrigeration
American Innovation & Manufacturing (AIM) Act
Phase down of HFC production and consumption
United States Environmental Protection Agency
608
SNAP
HFc
PHASEDOWN
American Innovation & Manufacturing (AIM) Act
A U.S. Environmental Protection Agency Program
High Efficiency Condensing Units (HECUs) & High Efficiency Evaporator Units (HEEUs)
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Thank You!
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Bringing California closer to
a decarbonized future.
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Appendix L: High-Efficiency Condensing Unit Qualified Products List

A spreadsheet containing the High-Efficiency Condensing Unit QPL can be found in the attached *Appendix L: High-Efficiency Condensing Unit Qualified Products List.xlsx* file.

Appendix M: High-Efficiency Evaporator Unit Qualified Products List

A spreadsheet containing the High-Efficiency Evaporator Unit QPL can be found in the attached *Appendix M: High-Efficiency Evaporator Unit Qualified Products List.xlsx* file.

Appendix N: Low-GWP Package Refrigeration Qualified Products List

A spreadsheet containing the High-Efficiency Evaporator Unit QPL can be found in the attached *Appendix N - Low-GWP Package Refrigeration Qualified Products List.xlsx* file.

End of Document